AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

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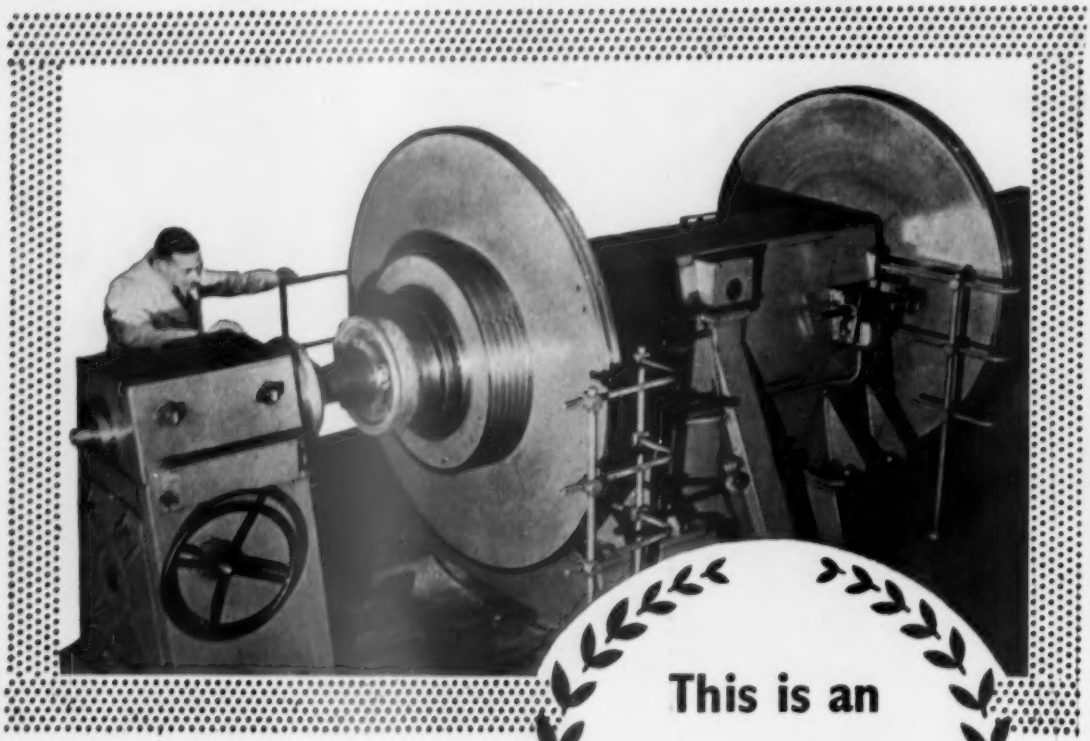

This is an international race winner

The men who control this machine have never thrilled to the drop of a chequered flag or earned the applause of a crowd at an International racing event. But they are continuously playing a vital part in helping to win International motor races.

On this 18·5 million ft-lbs capacity Inertia Machine Brake Liners are subjected, in terms of kinetic energy, to stresses far in excess of anything they would have to endure on any race track.

To us, research is the chief essential of brake liner manufacture. Mintex leadership, in fact, is based upon our policy of solving the braking problems of the future before they arise.

See our Stand No. 263 at the International Motor Show, Earls Court.

When high performance counts

you can rely on MINTEX

MINTEX BRAKE AND CLUTCH LINERS ARE MANUFACTURED BY BRITISH BELTING & ASBESTOS LIMITED, CLECKHEATON YORKSHIRE

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The lightweight CP-3008 Screwdriver, the tool with the supersonic exhaust.

AN AIR-POWERED SCREWDRIVER THAT'S REALLY QUIET!

power tool with Super-Sonic exhaust

Another boon to production men in every industry — a power driven NOISELESS screwdriver — the latest addition to the large range of designs introduced and manufactured by Consolidated Pneumatic.

The CP-3008 Screwdriver has a super-sonic exhaust. The exhaust sound waves have been raised to a frequency higher than that audible to the human ear. *The result is the quietest air screwdriver in the world.*

The clutch is adjustable *without the use of tools*, is smooth in action and held by a foolproof lock.

A built-in speed control gives the operator finger tip precision for the fine speed graduations which are so essential when driving small screws in delicate work.

This non-reversible screwdriver is only nine inches long and weighs under 2 lb. Combined with its light weight is greatly increased power. A great variety of attachments are available.

For all production line work use CP Noiseless Screwdrivers... light, powerful and QUIET

SUPER-SONIC EXHAUST
DIRECTIONAL EXHAUST
ADJUSTABLE CLUTCH
ALL STEEL
BUILT-IN SPEED CONTROL
FULL LINE OF ACCESSORIES

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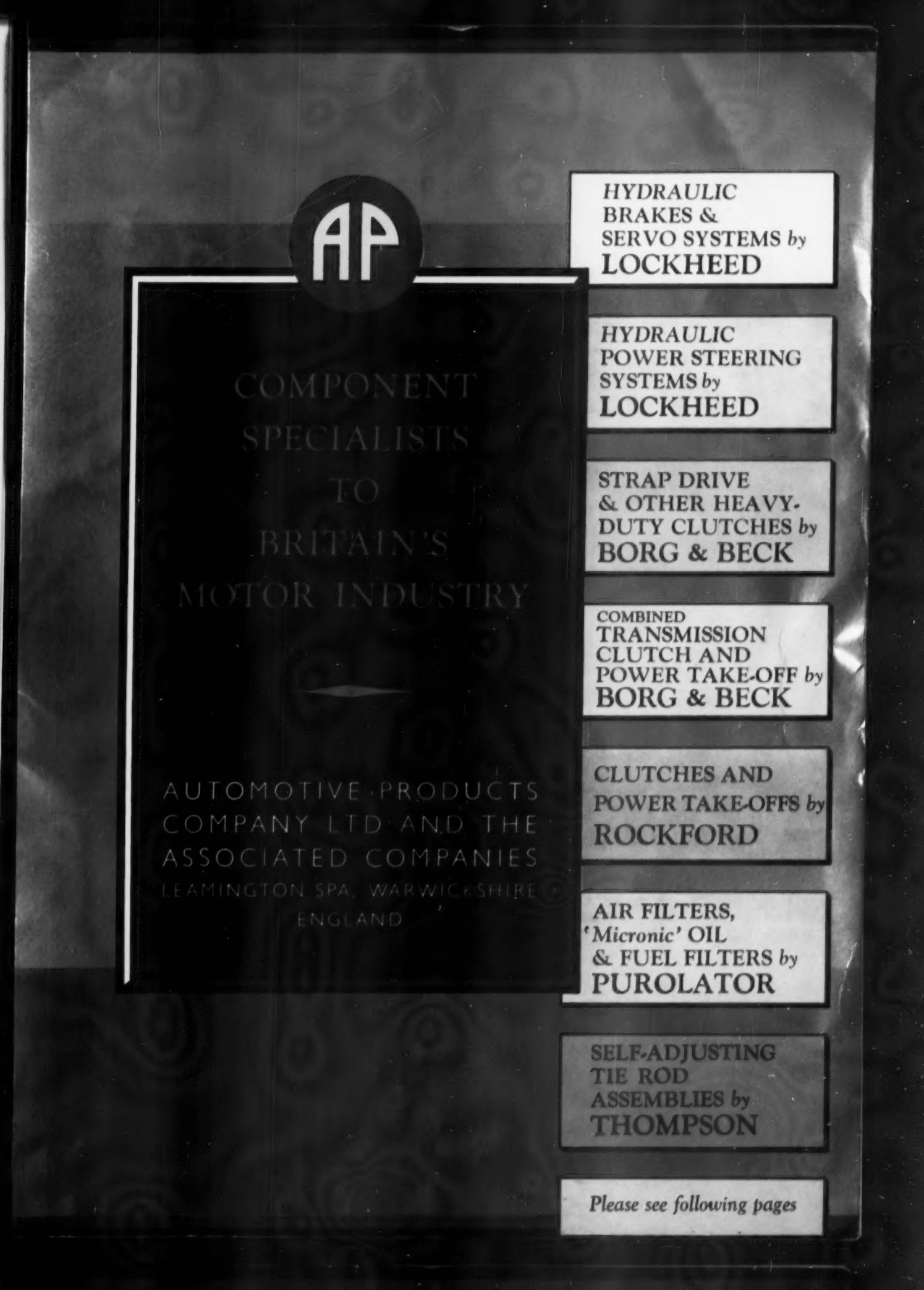
AP
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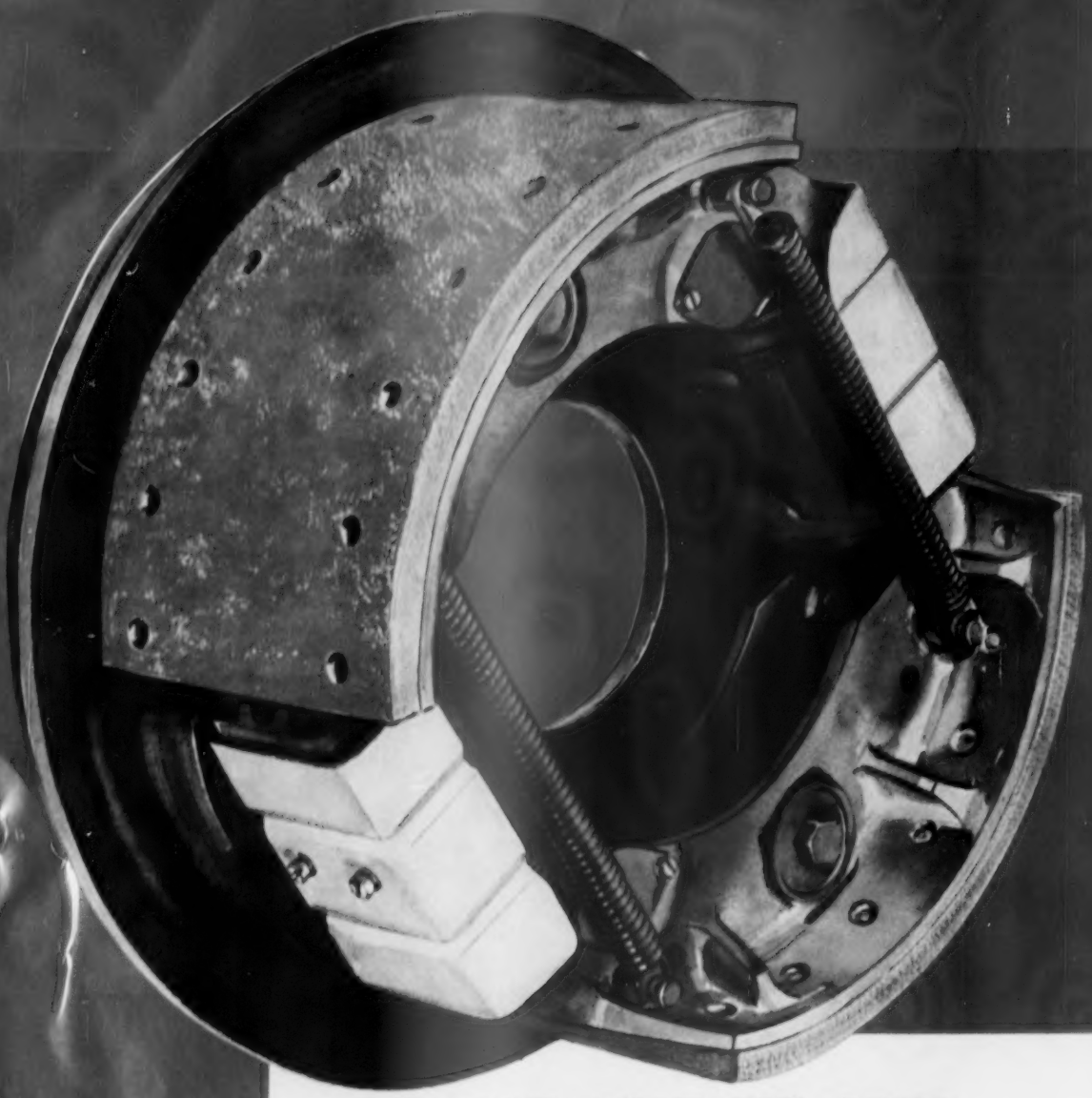
HYDRAULIC POWER STEERING SYSTEMS by LOCKHEED
STRAP DRIVE & OTHER HEAVY-DUTY CLUTCHES by BORG & BECK
COMBINED TRANSMISSION CLUTCH AND POWER TAKE-OFF by BORG & BECK
CLUTCHES AND POWER TAKE-OFFS by ROCKFORD
AIR FILTERS, 'Micronic' OIL & FUEL FILTERS by PUROLATOR
SELF-ADJUSTING TIE ROD ASSEMBLIES by THOMPSON
Please see following pages



FOR THE HEAVIES

A new two-leading shoe heavy-duty brake, 16¼ in. by 7 in. rear, 16¼ in. by 5 in. front, extending the existing wide range of Lockheed hydraulic brakes for commercial vehicles of all weights.

Medium duty brakes of 16 in. by 5 in. rear, 16 in. by 3 in. front, are also standardised.

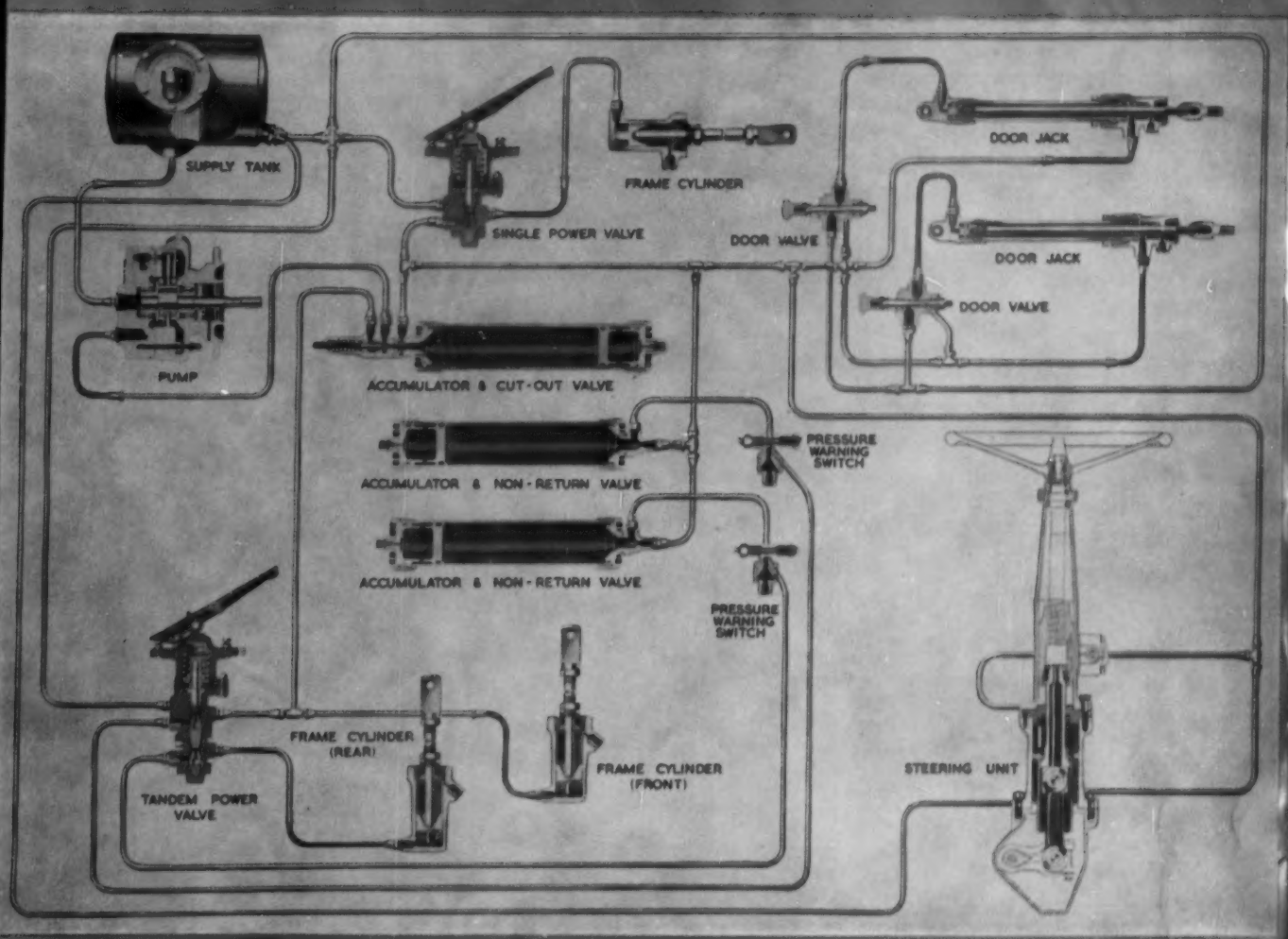
A transmission brake is available for use with the above.

To meet requirements in some overseas countries, three new compact Lockheed master cylinders of 1 in., 1¼ in. and 1½ in. bore are available with translucent fluid containers: these are additional to the previous range.

AUTOMOTIVE PRODUCTS COMPANY LIMITED

LOCKHEED: REGD. TRADE MARK FULLY PATENTED

LOCKHEED



SERVO SYSTEM

The Lockheed hydraulic power system is based on extensive development of Lockheed servo systems in vehicles, aircraft and industrial applications.

It operates the brakes, the gear control, the steering and the automatic doors. Two types of Lockheed hydraulic power steering systems are available, one with the hydraulic mechanism built into the steering column, the other applicable to existing manual steering systems.

In addition, there are the Lockheed hydraulic controls for clutch operation.

LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

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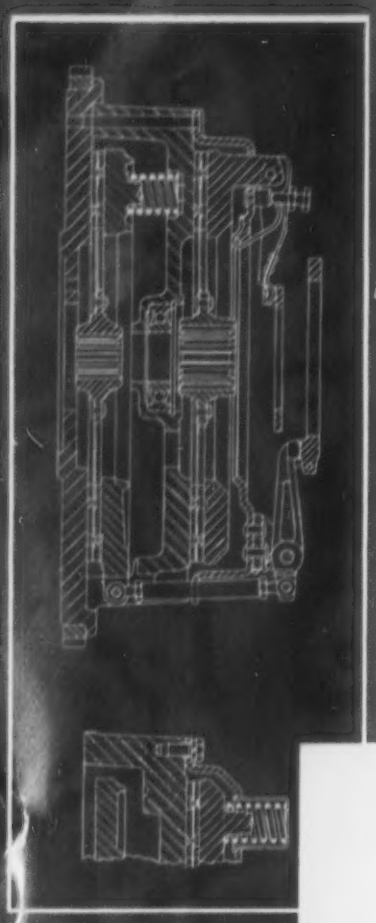
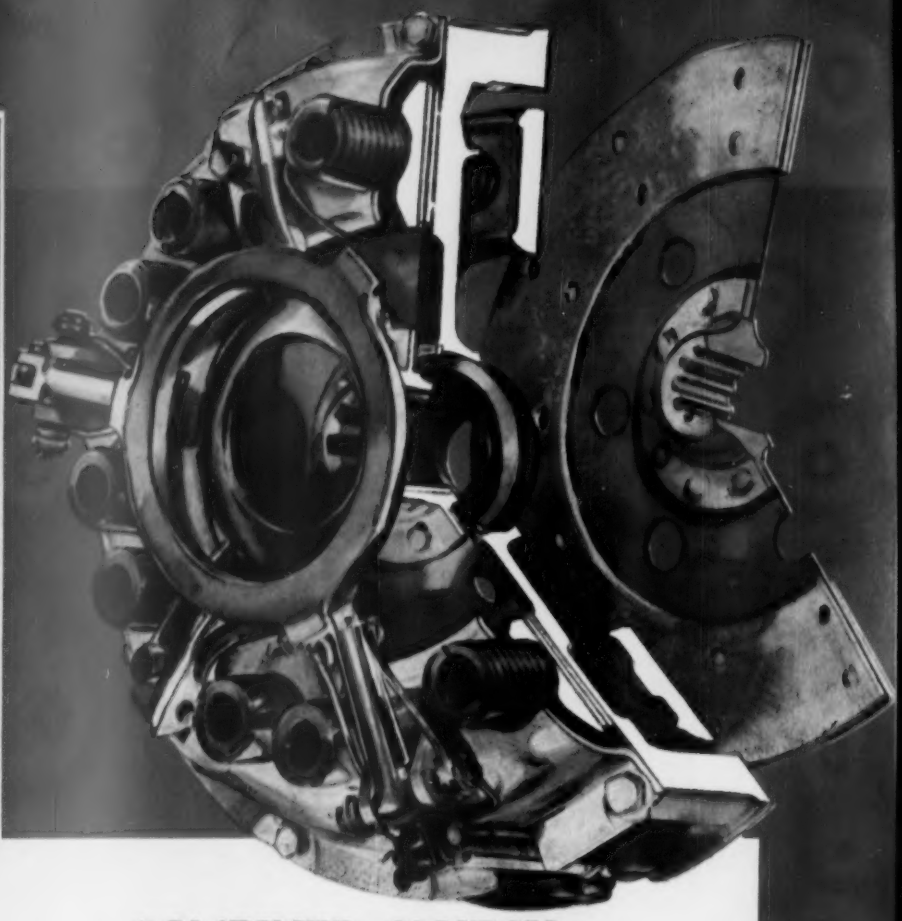
LOCKHEED





COMBINED CLUTCH AND POWER TAKE-OFF

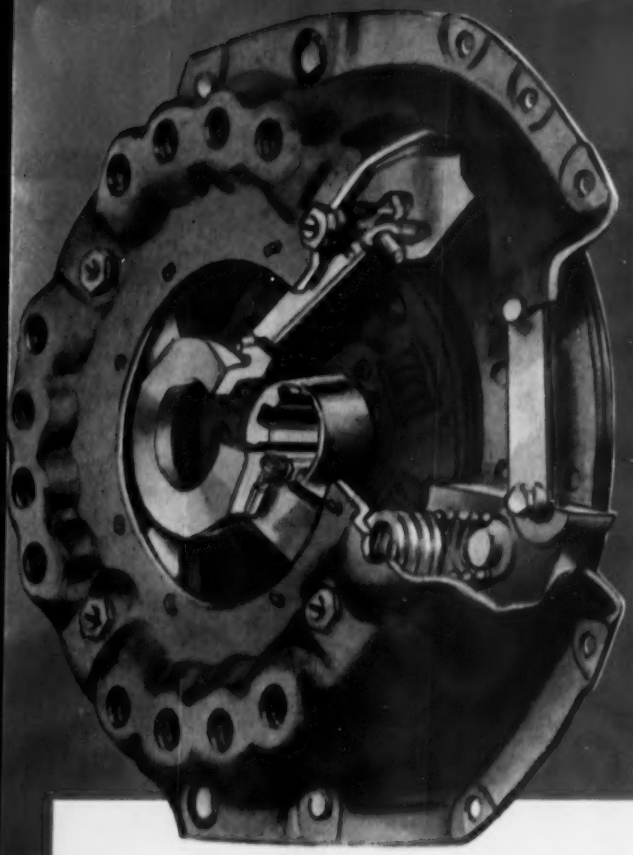
This dual purpose clutch meets a long-felt requirement for, in addition to the normal clutch for propulsion, it incorporates a second clutch for driving extra equipment used with road sweeping vehicles, agricultural tractors etc.

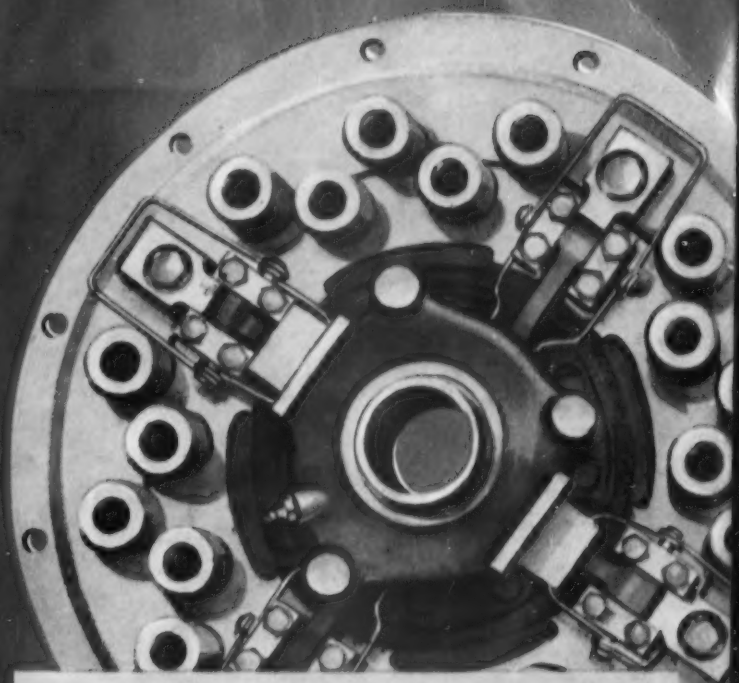
The two clutches have separate throw-out forks with ball-thrust bearings, and either one or both of the clutches may be run in the engaged or disengaged position.

Both clutches follow established Borg & Beck practice, which has maintained such a reputation for durability.

BORG & BECK COMPANY LTD.
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

BORG &





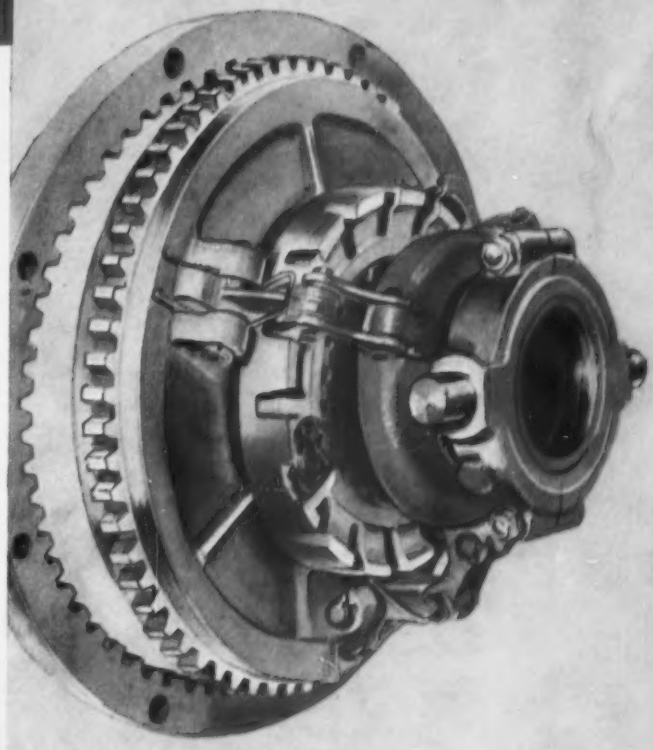
A COMPLETE RANGE OF HEAVY-DUTY CLUTCHES

Borg & Beck clutches are manufactured in a complete range for all commercial and passenger-transport vehicles. The strap-drive type is available in two sizes, the AS 12 in. and 13 in.; the R-type is made in 14 in., 16 in. and 18 in., both in single and twin-plate type. Light commercial vehicles are equipped with Borg & Beck clutches of automobile type, which are made in 6 sizes from 6¼ in. to 11 in.

Taking the entire range of Borg & Beck clutches, they cover torque capacities from 38 lb./ft. to 1600 lb./ft.

BECK

REGD. TRADE MARK BORG & BECK



Rockford clutches & power take-offs, in a range of sizes.

ROCKFORD

New
AIR
PUROLATOR
Dry Type
MICRONIC
FILTER

FILTRATION

. . . with the dry type 'Micronic' paper element

The famous 'MICRONIC' paper element, pioneered and perfected by Purolator, has now been developed to give a new standard of air filtration. This new filter unit is the essence of efficiency and simplicity.

The Purolator dry type 'Micronic' air filter arrests the air-borne abrasives without appreciable throttling of the air, and continues to do so for long periods. When the element eventually chokes it may be cleared with a compressed air jet from inside.

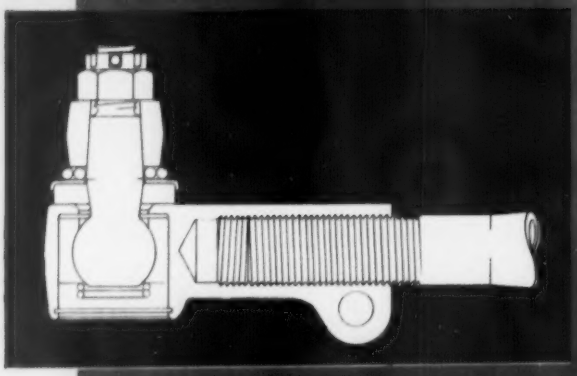
In addition, there is also the full range of oil and fuel filters, already famous for protecting the engine against destructive abrasives.

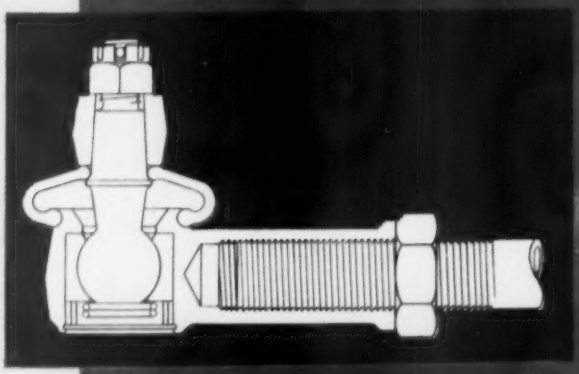
AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

Registered Trade Marks: Purolator, Micronic

PUROLATOR

FOR HEAVY VEHICLES





The Thompson eccentric-type of tie-rod is made in a range of sizes, 1 in., 1⅛ in., 1¼ in. and 1½ in., to suit vehicles having front axle weights ranging from 4,000 lb. to 8,500 lb.

The illustration above shows the well-proved construction.

The line drawings on the right show, at top, the standard tie-rod end allowing slight angular movement, and below, a typical drag link end fitting which provides a large angular movement of the ball pin.

Both illustrations relate to the eccentric-type illustrated at the top. Thompson 'dual' types are used on the lighter vehicles.

AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

Thompson Self-adjusting

STEERING ROD ASSEMBLY

TURN IT UP!

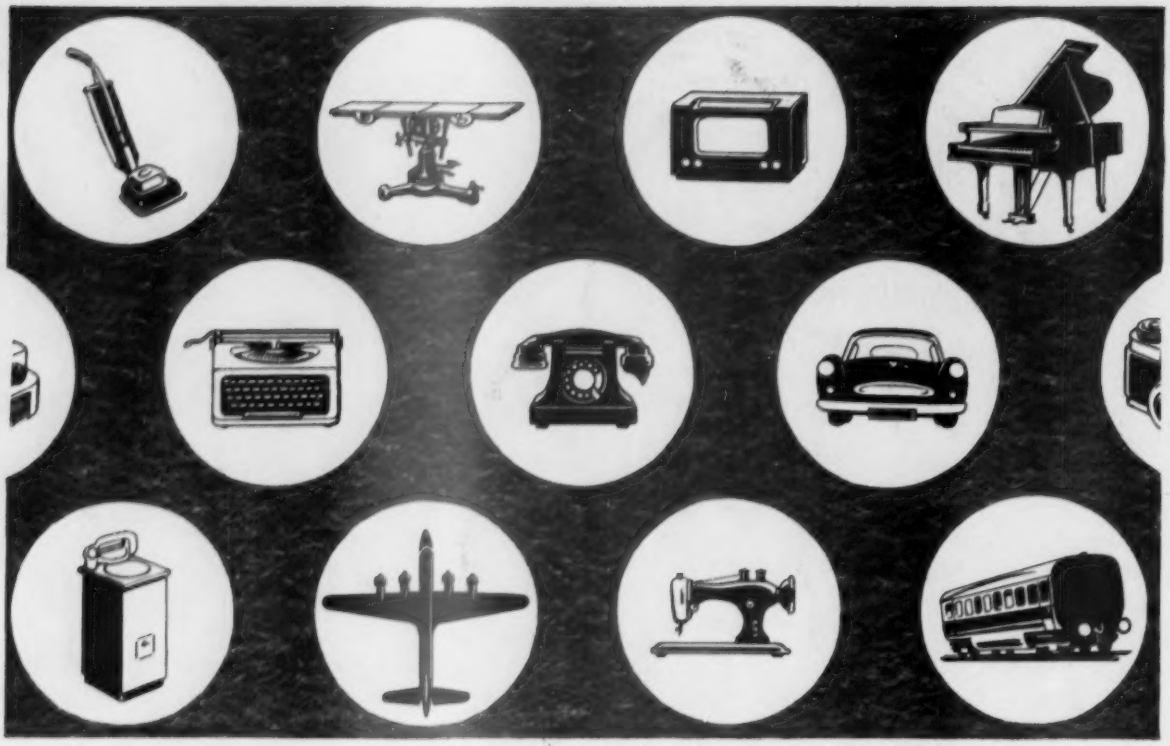
One way up, the new Holroyd VERSO is a fine *underdriven* speed reducer. The other way it's a fine *overdriven* reducer. It's two units in one, with solid feet for mounting either way up. There are also other ways of mounting it, and of using the feet as a platform for accessories. Whichever way you use it, the VERSO will run continuously under the heaviest loads and the toughest conditions. This latest Holroyd gearbox is available now for quick delivery. Do you want to know more about it? We'll be glad to send you a leaflet giving all the technical details.

The VERSO is a 2¼" centre distance worm gearbox designed for heavy duty industrial work. Standard ratios are from 5/1 to 70/1 and depending on the ratio 3¼ h.p. can be transmitted. The VERSO is suitable for input speeds up to 3,000 r.p.m. The wormwheel is made from centrifugally cast Holfos Bronze and the worm from nickel case hardening steel.

THE VERSO WORKS **BOTH** WAYS

JOHN HOLROYD & COMPANY LIMITED. MILNROW. LANCS. TELEPHONE: MILNROW 55322

CBC V1



The Meadowfelt service is an integral part of the industrial picture

Service is the keystone of the Meadowfelt organisation. The result is that more and more industrial companies are specifying Meadowfelt for filters, seals, gaskets, washers, joints, shock-absorbent mounting—and the hundred-and-one other industrial applications of felt. Meadowfelt can be made to your precise specifications or you can leave it to us to produce felts that are right for the job. Meadowfelt can be made as hard as a board or as light as thistledown; it can be die-cut or punched; it is invaluable in packaging.

Meadowfelt is used in:

Aircraft
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Surgical appliances
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Typewriters
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and in all kinds of industrial products large and small

Meadowfelt

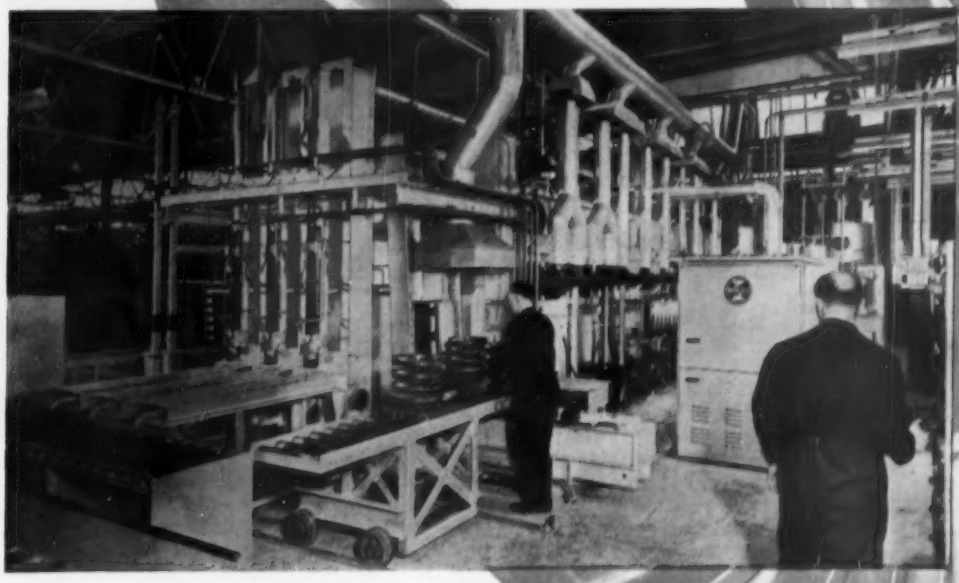
Tested and Trusted by Industry

THE LONG MEADOW FELT COMPANY, KIDDERMINSTER—THE FELT DIVISION OF CARPET TRADES LIMITED

Continuous carburising furnace for gears

at E.N.V. ENGINEERING COMPANY LIMITED

This new Birlec continuous gas carburising furnace, installed at the Willesden works of E.N.V. ENGINEERING COMPANY LIMITED, is employed for case-hardening heavy gears and pinions, achieving a production rate exceeding 600 lb net per hour. Loaded on heat-resisting trays, components are conveyed through the furnace on three parallel tracks, each of which may be set for a different carburising cycle. Work may be withdrawn manually for press quenching, or each tray-load may be quenched automatically. Doors, pushers, and transfer-mechanisms are all hydraulically actuated in correct sequence under automatic control. Two similar installations are now under construction for FORD MOTOR CO. LTD.



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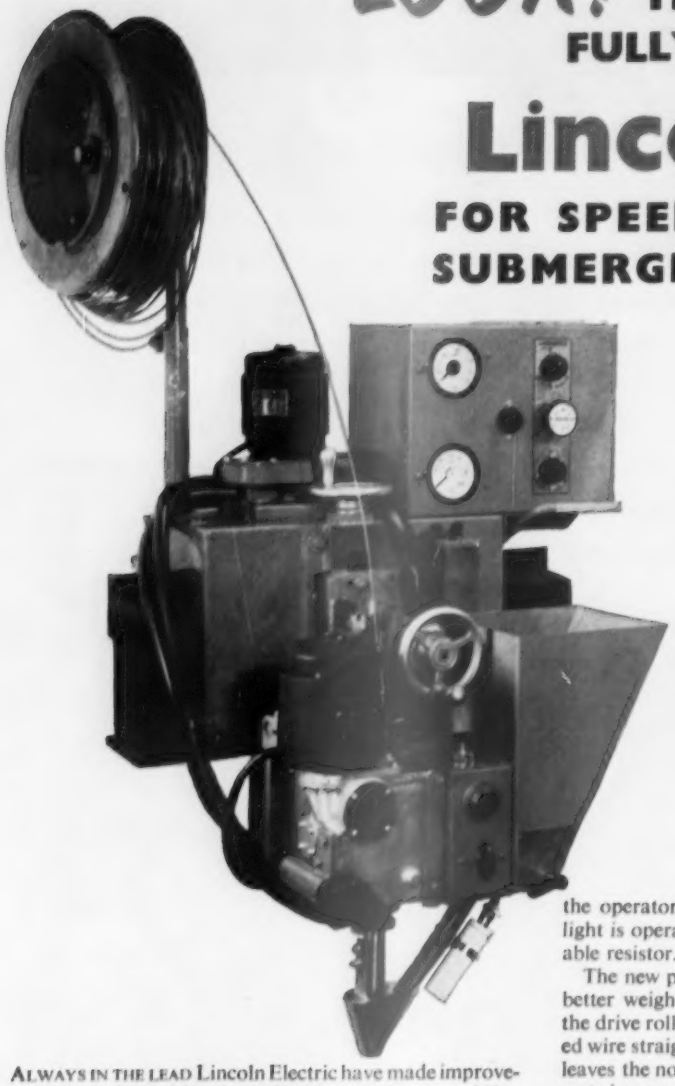
LOOK! THE NEW IMPROVED FULLY-AUTOMATIC

Lincolnweld

FOR SPEEDIER AND EASIER SUBMERGED-ARC WELDING



The control box position gives better speed range changing and is fitted with full-scale reading Ammeters and Voltmeters (voltmeters 0-60V., ammeters 0-800 or 0-1500, complete with shunt). The new position of the hand control box improves visibility and control.

ALWAYS IN THE LEAD Lincoln Electric have made improvements to their 'Lincolnweld' submerged-arc welding equipment which will cut costs, speed production and produce a better quality weld.

The new 'Lincolnweld' is specially strengthened to avoid whip. Rollers are fitted on the travel carriage to ensure lateral stability. A double slide is fixed to the strengthened travel carriage which allows vertical movement up and down of 6" and horizontal movement through 4½". The wire feed gear-box, control-box and hopper can be rotated through 90° to cope with circumferential seams.

A new feature is the adjustable spot light which helps the operator to see the welding point. The arrowpoint light is operated from 115V DC at 12V through a variable resistor.

The new position of the wire reel carrying stand gives better weight distribution and improves the feeding to the drive rolls and welding nozzle. A special hand adjusted wire straightener ensures that the wire is straight as it leaves the nozzle. The rollers are suitable for either single or twin arc welding.

On the flux hopper a Flap valve replaces the quadrant valve enabling solenoid control to be applied to the flux feed. The new flux tube nozzle design is streamlined and circular in section. Two types can be fitted, type A. is suitable for Lincolnweld wire $\frac{5}{64}$" to $\frac{1}{8}$", type B. for Lincolnweld wire $\frac{3}{32}$" to $\frac{7}{32}$". A flux retainer can be fitted round the nozzle to ensure retention of correct volume of flux at the welding point. The flux-feed tube from hopper to retainer is made from a corrugated tube to give greater flexibility.

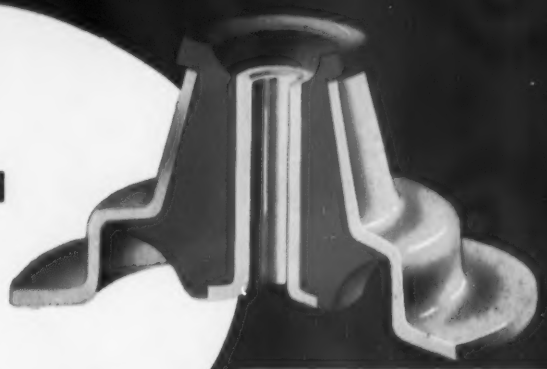
LINCOLNWELD

Fully Automatic Submerged-Arc welding equipment

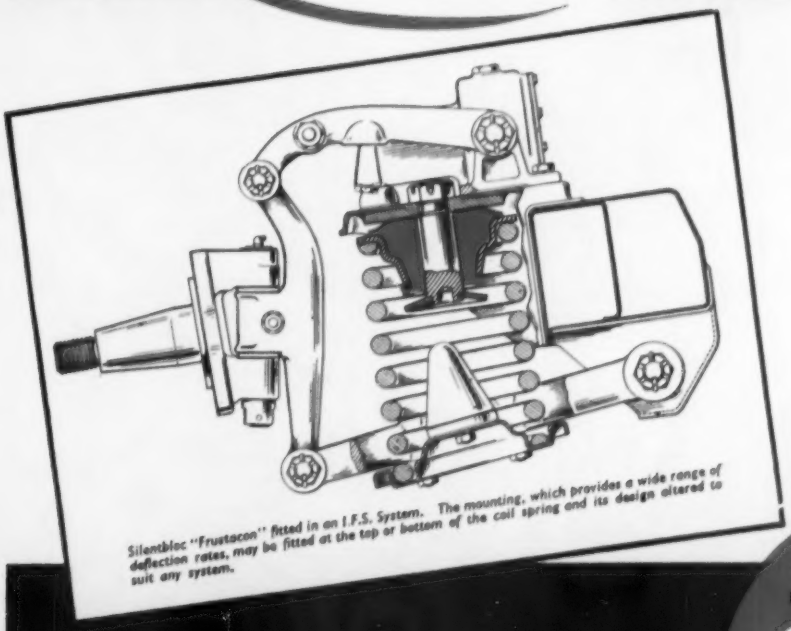
LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920

Silentbloc FRUSTACON..

. . . the first scientifically designed flexible mounting fitted to the I.F.S. of a Production Car



The 'Frustacon' mounting fitted to the I.F.S. of the Rover '75'. Sectioned to show rubber.



Silentbloc "Frustacon" fitted in an I.F.S. System. The mounting, which provides a wide range of deflection rates, may be fitted at the top or bottom of the coil spring and its design altered to suit any system.

To minimise the transmission of road noise to the body by the coil springs, Silentbloc Frustacon mountings have been incorporated in the I.F.S. of the Rover '75'. This notable step forward in the reduction of noise is another example of co-operation between car manufacturers and Silentbloc Ltd.

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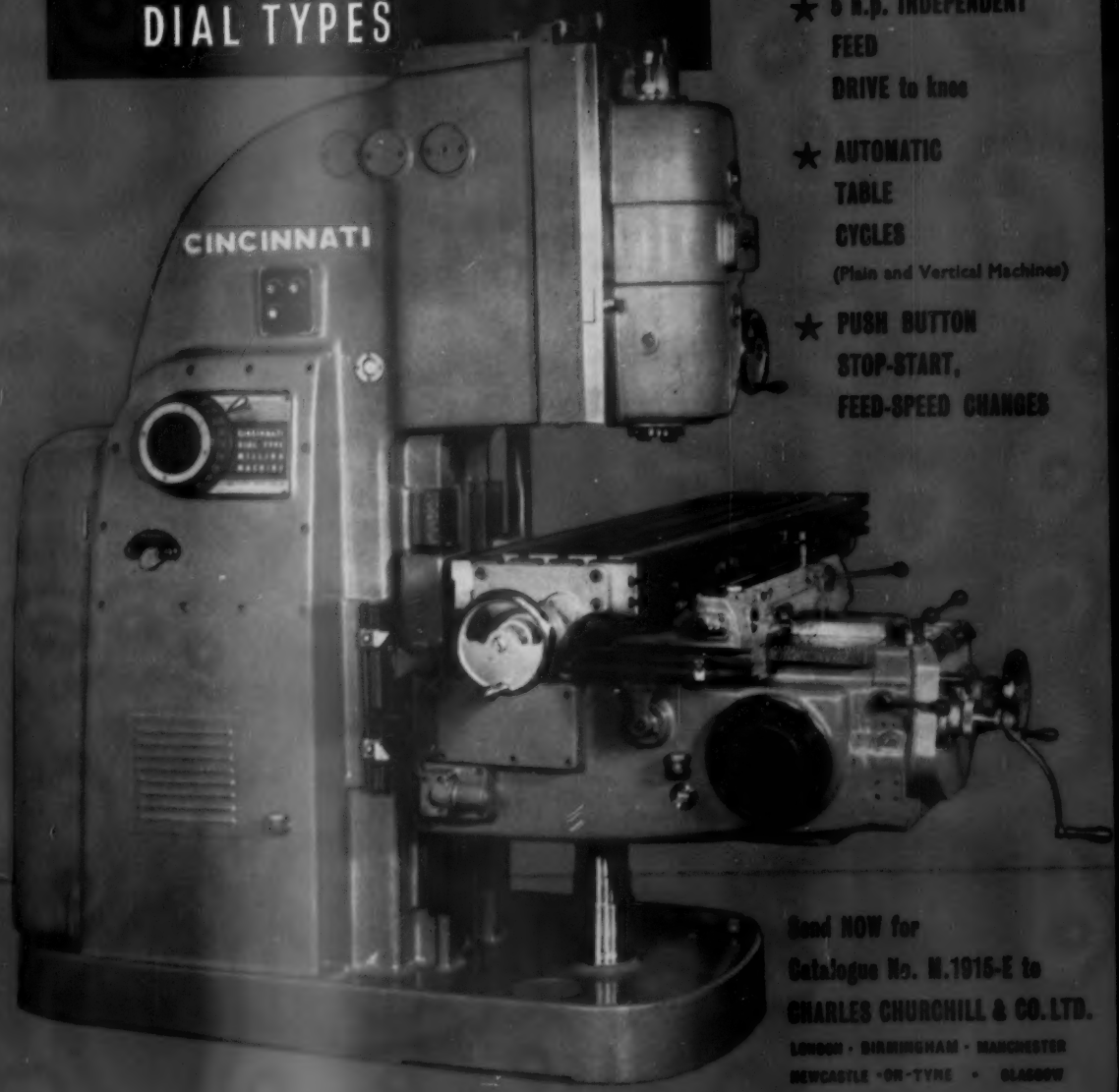

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(20 h.p. for Universals)

★ 6 h.p. INDEPENDENT FEED DRIVE to knee

★ AUTOMATIC TABLE CYCLES
(Plain and Vertical Machines)

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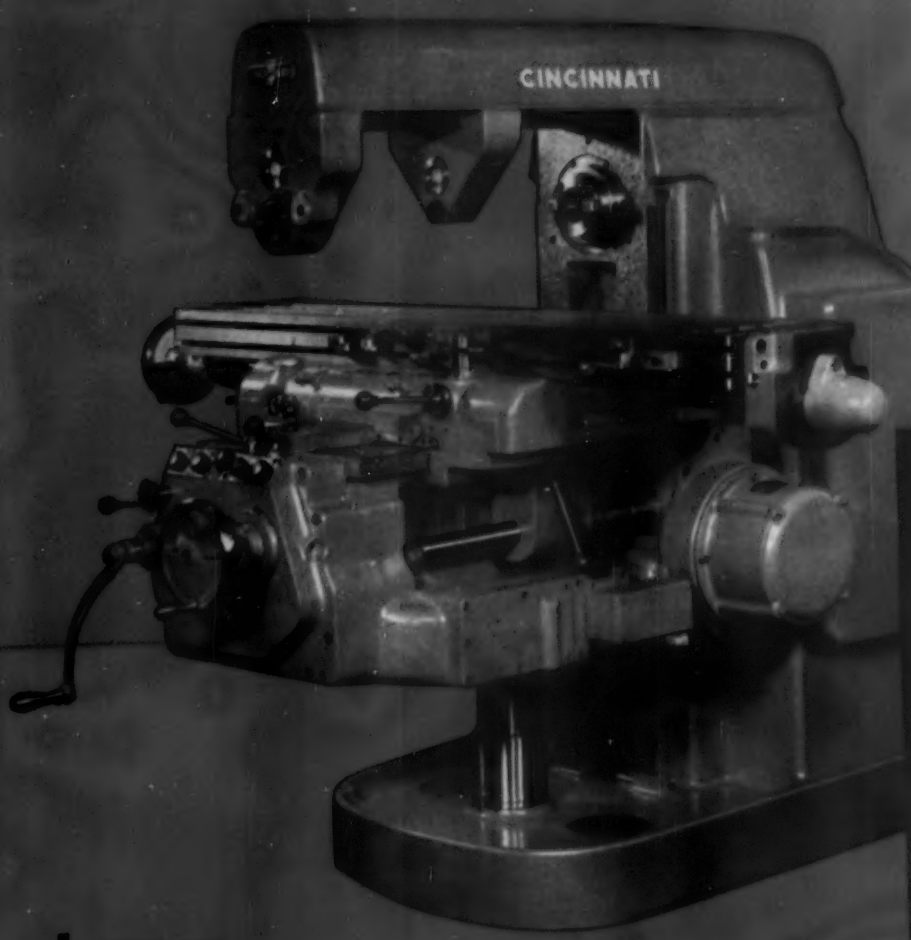

CINCINNATI

HERE ARE A FEW "VITAL STATISTICS"

Sizes	No. 5. Plain	No. 5. Univ.	No. 5. Vert.	No. 6. Plain	No. 6. Vert.
TABLE	94½" x 20"	94½" x 20"	94½" x 20"	104½" x 20"	104½" x 20"
RANGES Longitudinal Cross Vertical Vert. Head	50" 14" 20" —	52" 14" 19" —	50" 18" 20" 8½"	60" 14" 20" —	60" 18" 20" 8½"
SPEEDS - r.p.m. FEEDS-in./min.	14-1,400 ½"-90"	14-1,400 ½"-90"	14-1,400 ½"-90"	14-1,400 ½"-90"	14-1,400 ½"-90"
DRIVE Spindle-h.p. Table-h.p.	40-20* 5	20 5	40-20* 5	40-20* 5	40-20* 5
WEIGHT - lbs.	12,700	13,700	14,500	13,000	14,800

*40 h.p. at high speeds ; 20 h.p. at slow speeds (or 20 h.p. at all speeds, if preferred)

CINCINNATI MILLING MACHINES LIMITED · BIRMINGHAM 24

impact wrench
SIZE 24

Basically designed as a Nut Setting Tool, this Impact Wrench may be effectively used with the available attachments for screwdriving, tapping, drilling, grinding, wire-brushing or sanding.

R29

Extra strong in design and construction this tool incorporates longer normal working life with minimum maintenance.

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(2)
and as you asked us to take extra care over the flywheel, we used the "sandwich" technique with Ilford Industrial X-ray films B and C. We found that using the two films in one cassette gave us the finest results possible; the Type B film took care of the thick sections and Type C of the thinner web.
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With regard to your enquiry about a handy reference work on industrial radiography, we are sure you will find a great deal of useful information in the enclosed Ilford publication. This is a spare copy and you need not trouble to return it.
Yours faithfully,
Chief Inspector
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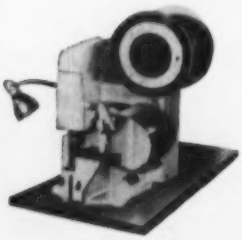
Certi-crimp hand tool. Positive closure ensured.

Pneumatic hand tool eliminates operator fatigue.



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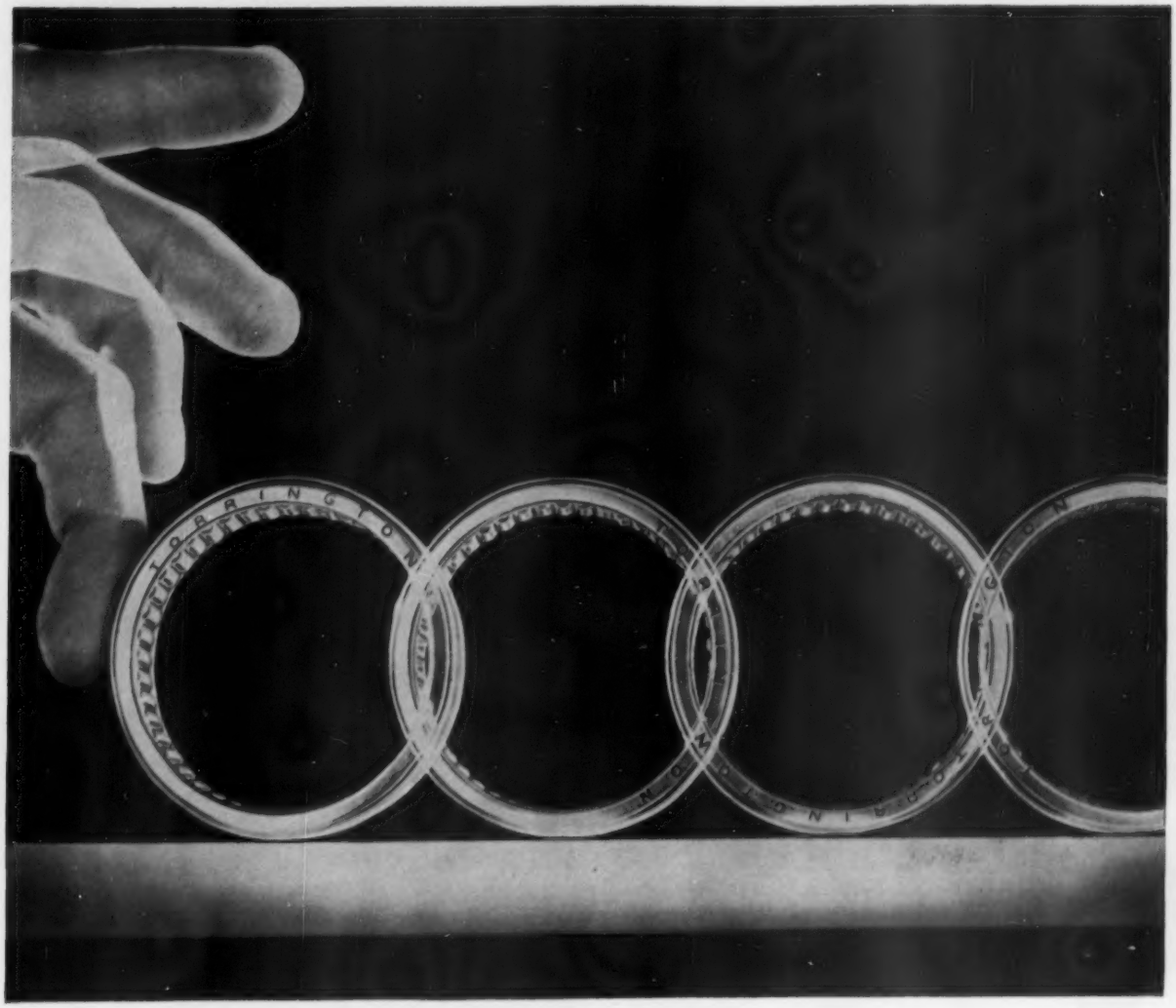

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The Torrington Needle Bearing has a low coefficient of friction — both in starting and in running. Therein lies a boon for designers and manufacturers. Unlike a plain bearing which has a fairly high starting coefficient of friction — the Needle Bearing needs no more push to "get it going" than to "keep it going". Nor are the frictional characteristics of the Needle Bearing dependent upon maintaining a continuous oil film as in a plain bearing. This all adds up to inexpensive and simpler designs, smaller drive motors and dependability. For twenty years our engineering department has helped designers and manufacturers throughout industry to adapt the unique characteristics of the Needle Bearing to their products. Let us help you make the Needle Bearing "standard equipment" in yours.

These features make the **TORRINGTON NEEDLE BEARING** *unique*

- ★ *Low coefficient of starting and running friction*
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- ★ *Compactness and light weight*
- ★ *Runs directly on hardened shafts*
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He's just going to use another of those

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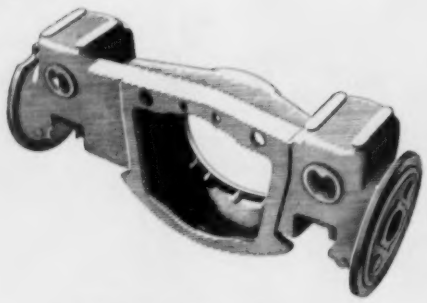

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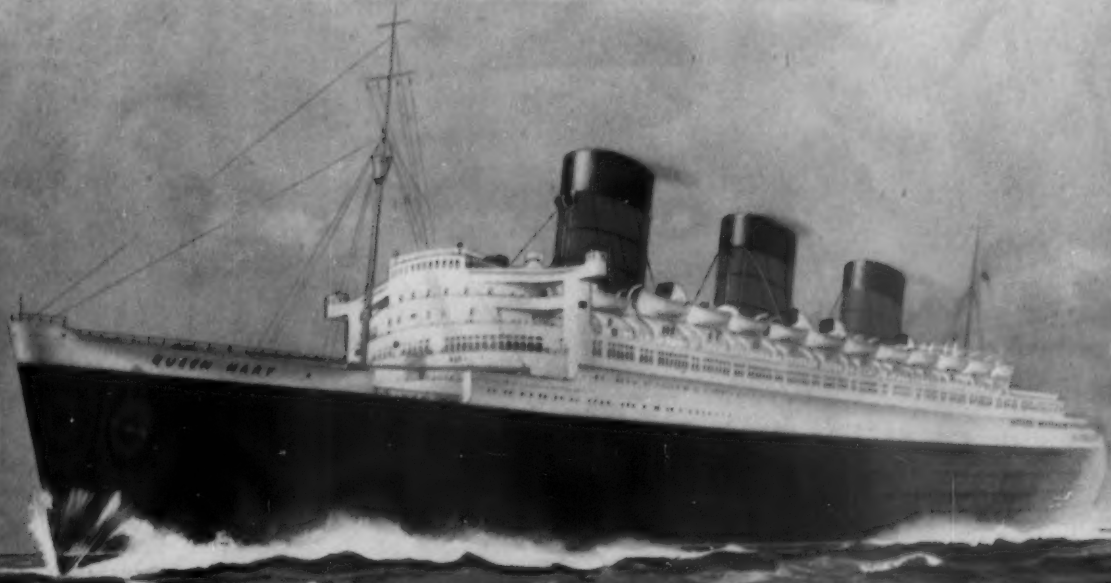

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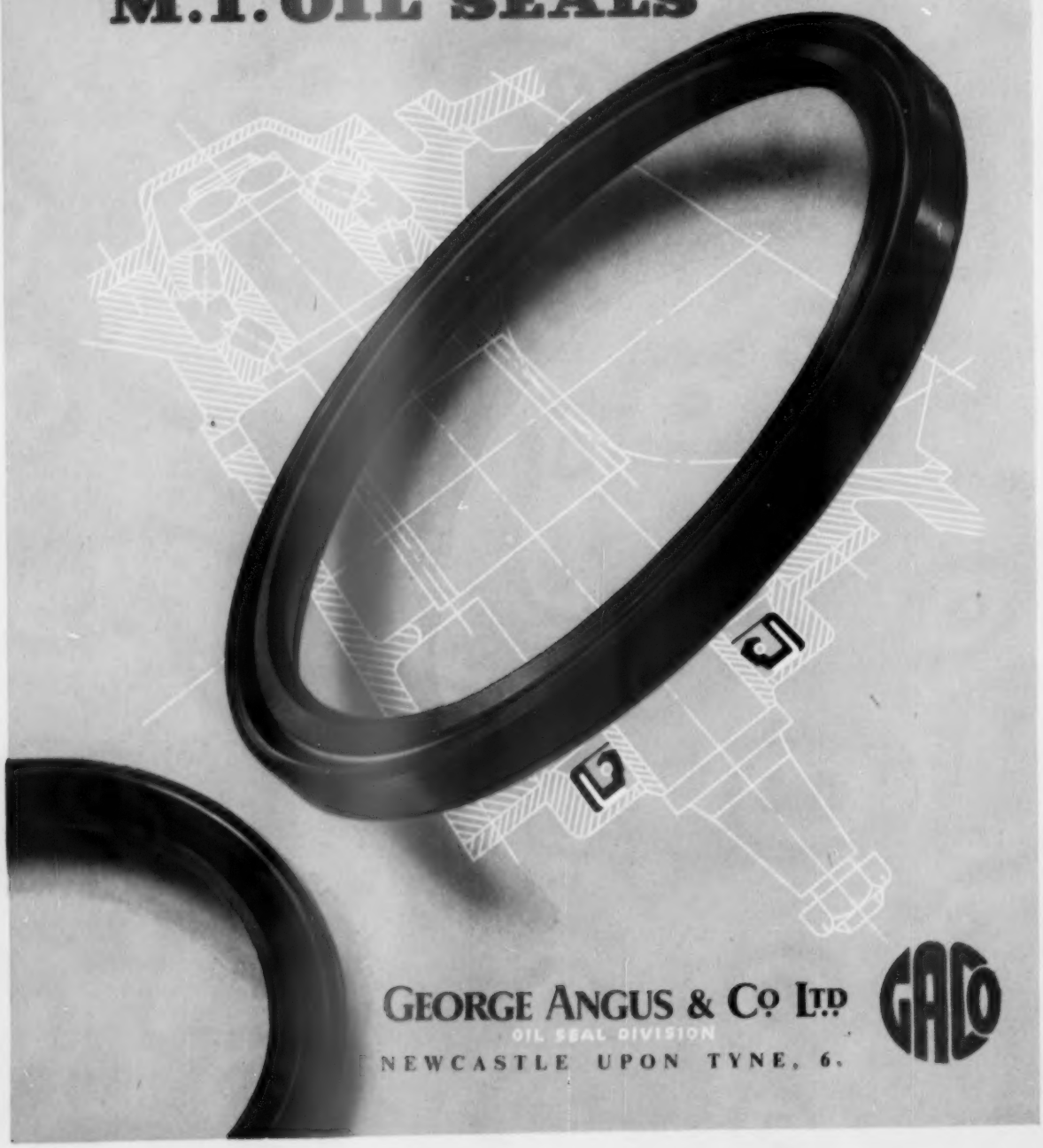

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Recent developments in abrasives now enable one man and a nylon-reinforced hub wheel to tackle more than 15 different notching, cutting and dressing operations without once changing the wheel. In trimming castings, for example, feed-heads and gates can be cut off with the edge, while mould marks and other rough patches are smoothed off with the face. The new type of wheels are certainly versatile, more productive and time-saving. But they do demand a grinder capable of high speeds and great power if you're to benefit fully from this new development.

The Atlas Copco LSS 81 High-Capacity Disc Grinder has the speed, has the power. The new vane-type air motor has ample power to maintain the peripheral speed of 15,000 ft./min. necessary to obtain the maximum output from these wheels. Yet for all its power it weighs as little as 11 lbs., is quiet, simple to operate, cheap to run and safe.

Make the most of the new developments in abrasives.
The Atlas Copco LSS 81 High-Capacity Disc Grinder does!

An Atlas Copco LSS 81 Disc Grinder fitted with one of the new nylon-reinforced hub wheels smooths flame-cut edges on a heavy steel plate.

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An Atlas Copco LSS 81 Disc Grinder cutting through piping. This grinder realises the high-productive potentialities created by recent developments in abrasives.

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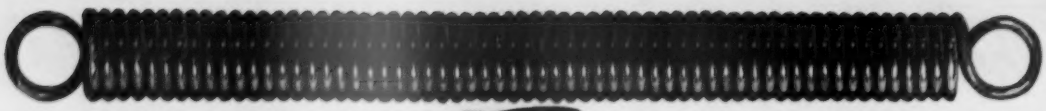
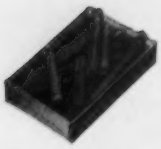
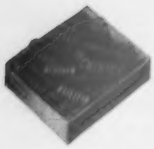
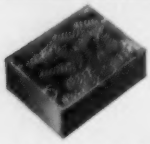




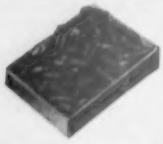
No. 760. 3 doz. Assorted Light Compression Springs 1″ to 4″ long, 22 to 18 S.W.G., ¼″ to ½″ diam. 6/6 each.



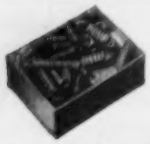
No. 98A. 3 doz. Assorted 1″ to 4″ long, ⅛″ to ¾″ diam., 19G to 15G. 5/6 each.



No. 757. Extra Light Compression, 1 gross assorted, ½″ to ¾″, ¼″ to 2″ long, 27 to 20 S.W.G. 15/- each.



No. 388. ½ gross Assorted Small Expansion Springs. ⅜″ to 1⅛″, 18G to 21G. 9/6 each.



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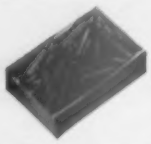
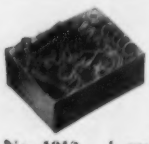


No. 466. ½ gross Assorted Small Expansion Springs ⅜″ to 1½″ long, 3/32″ to 3/16″ diam., 21G to 24G. 6/6 each.



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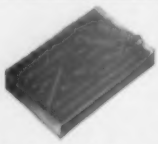

No. 753. 3 doz. Assorted Light Expansion ½″ to ¾″ diam., 2″ to 6″ long, 22 to 18 S.W.G. 10/6 each.

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vehicle springs

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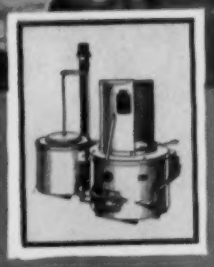

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construction, proved successful through
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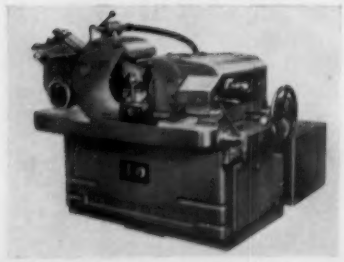

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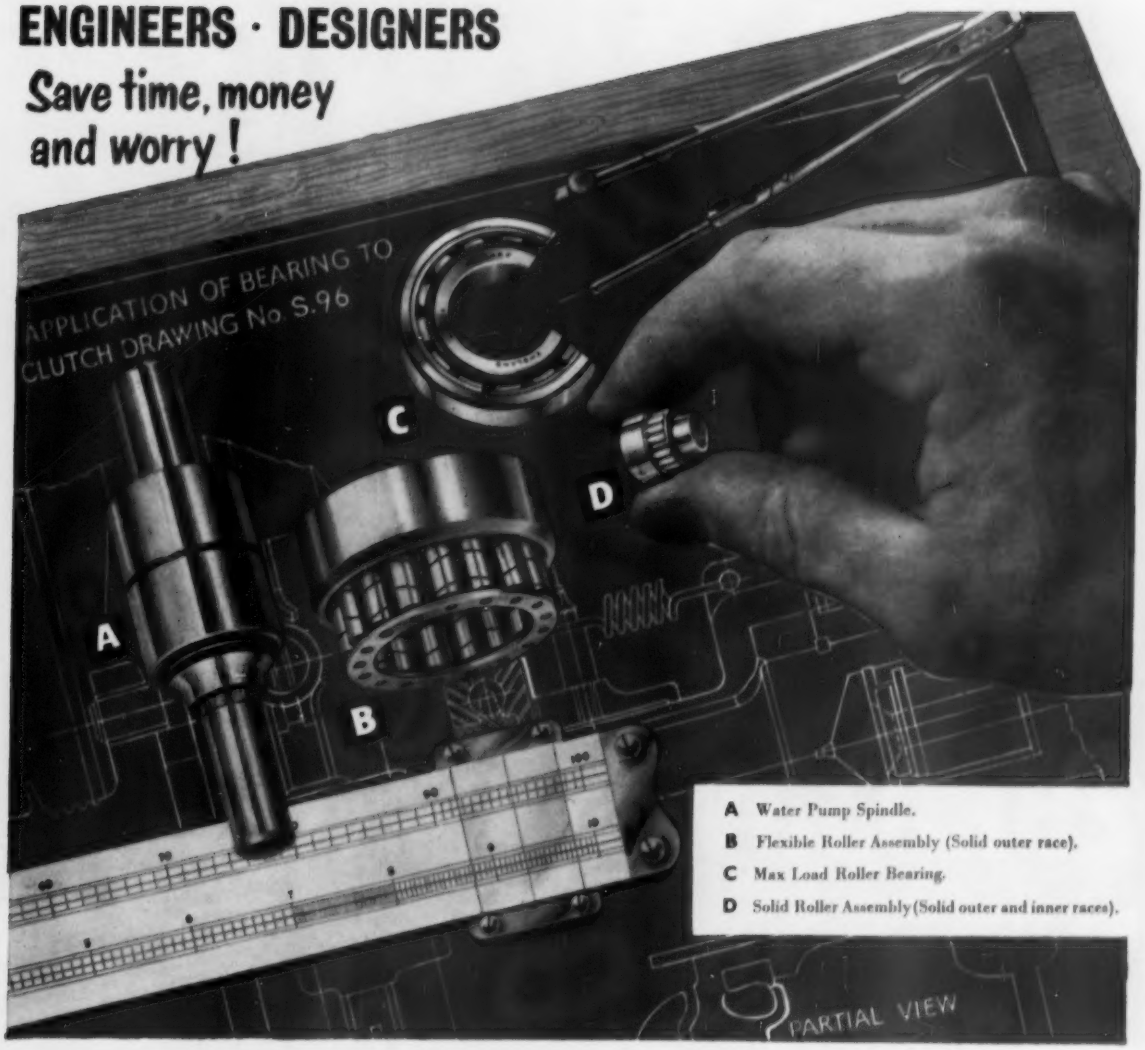

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C Max Load Roller Bearing.
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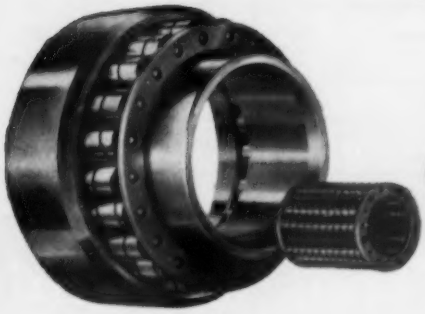

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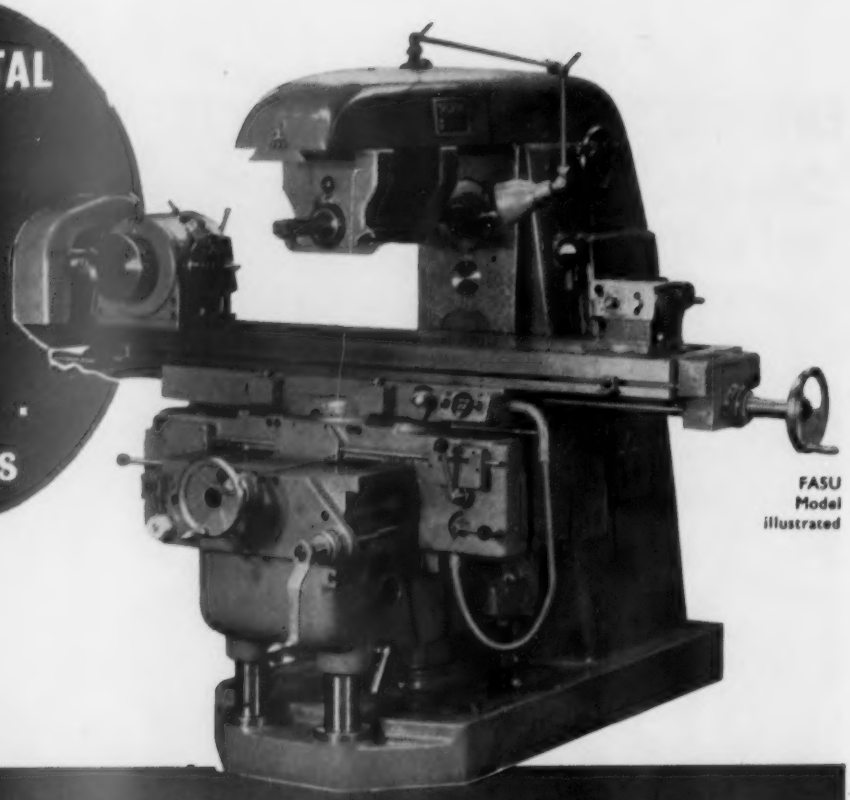

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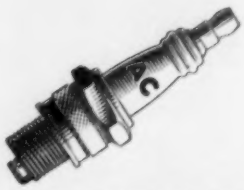
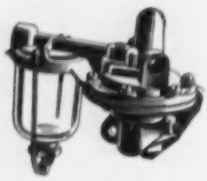


AC SPARK PLUGS



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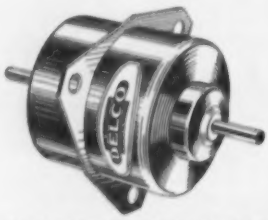
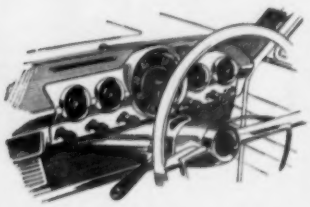


DELCO ELECTRIC MOTORS



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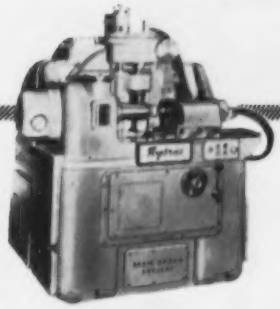
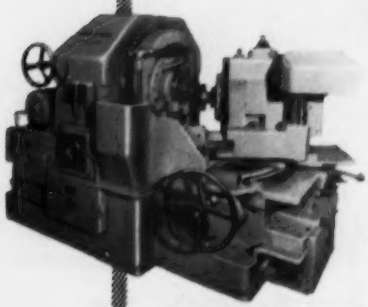


NO. 7 HYDRAX PRODUCTION GEAR HOBBING MACHINE

NO. 14 HYDRAX PRODUCTION GEAR HOBBING MACHINE



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Nos. 7 and 14 Hydrax automatic high speed production hobbing machines for gears up to 7 and 14 inches diameter.

PH30 automatic high speed production hobbing machine for gears up to 30 in. diameter.

S6H and S12H automatic production shaving machines for gears up to 7 and 12 in. diameter.

Spiral bevel and hypoid roughing, finishing, jobbing, testing and lapping machines.

S6H PRODUCTION GEAR SHAVING MACHINE

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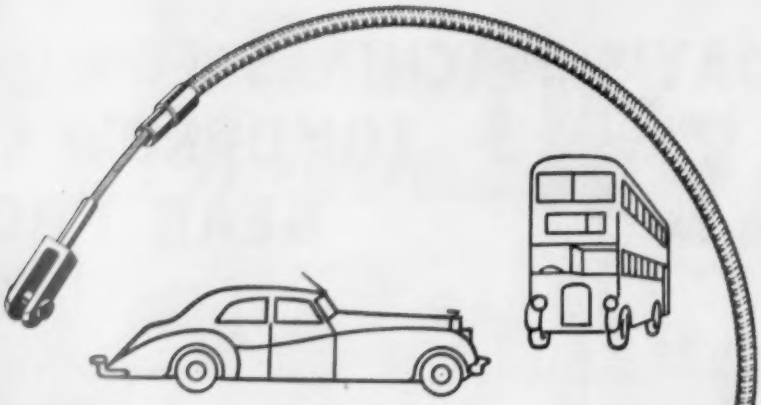

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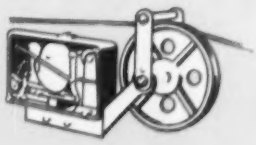

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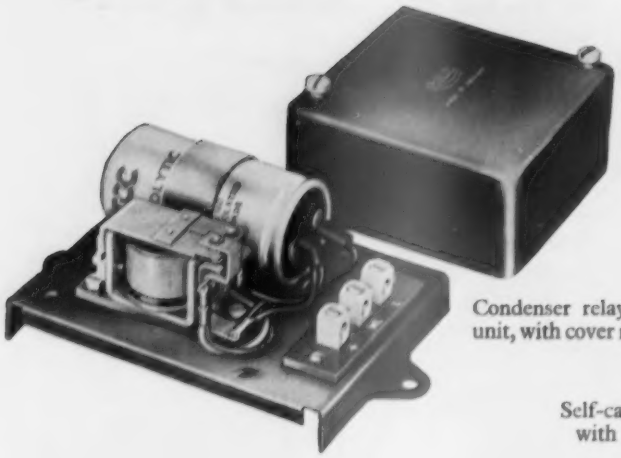
236

NEW CONDENSER RELAY TYPE "CRF"



Condenser relay flasher unit, with cover removed

Self-cancelling switch, with warning light

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FOR COMMERCIAL VEHICLES

C.A.V. Flashing Indicator Equipment is designed especially for use on public service and transport vehicles, and is robust to ensure trouble-free operation. The new flasher unit is light, compact, and completely reliable, with only one working part, the relay, operated through an electrolytic condenser which is hermetically sealed and unaffected by temperature or moisture. Optical design of lamp units is carefully planned to give maximum visibility and attention value. Three types of lamp are available: circular for front or rear mounting; side-mounting type; and arrow type. All are single purpose lamps, giving unmistakable signals even in bright sunlight. Self-cancelling switch (illustrated) with adjustable time delay, or simple hand-cancelling type as required.

STAND No. 252

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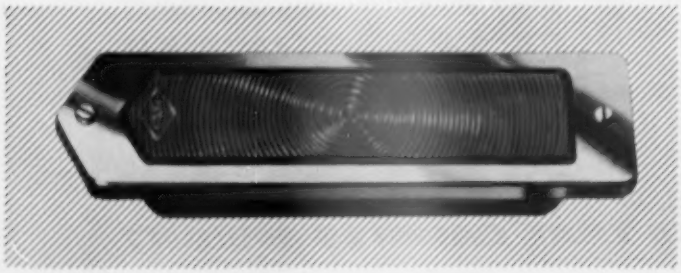

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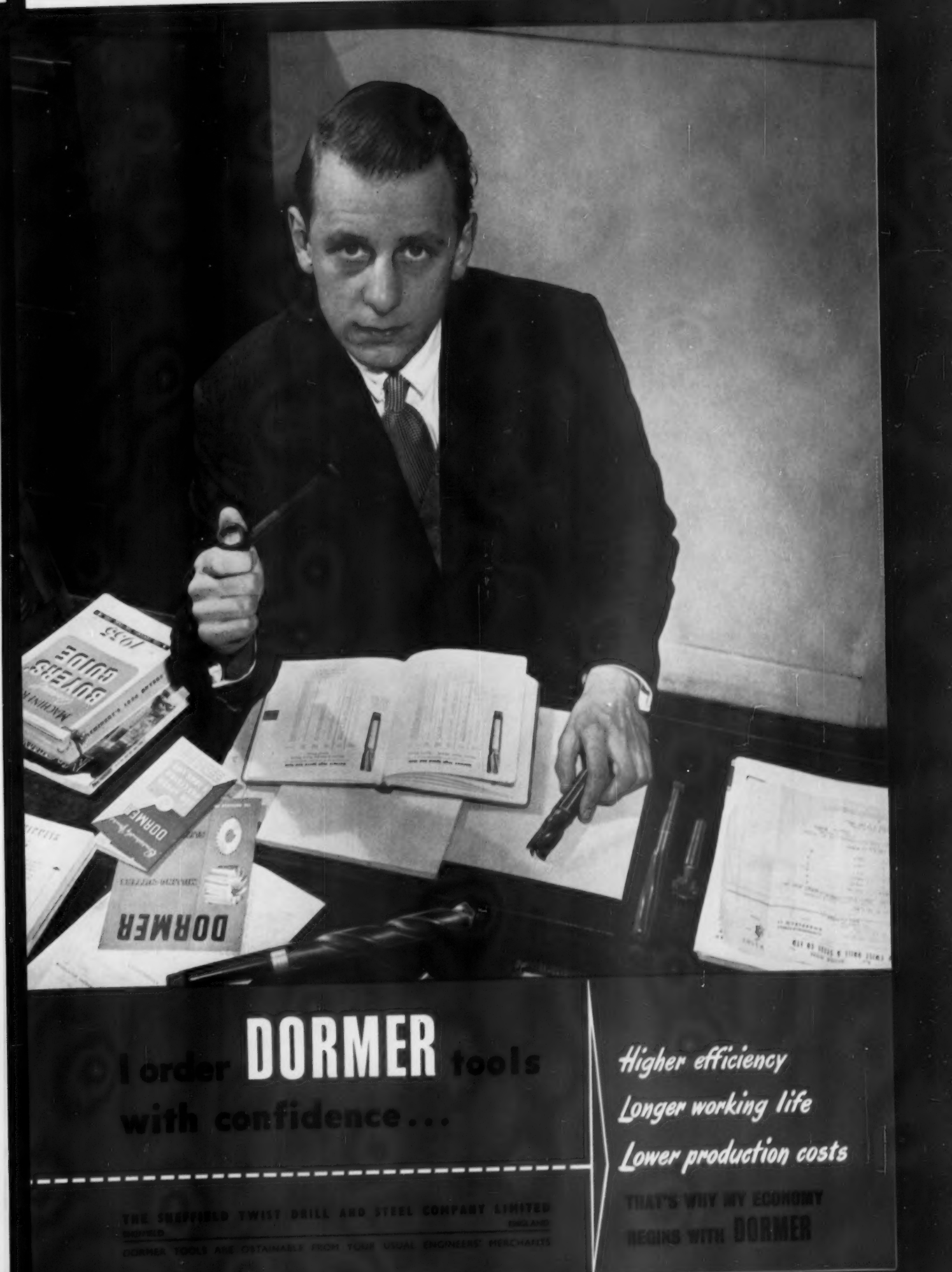

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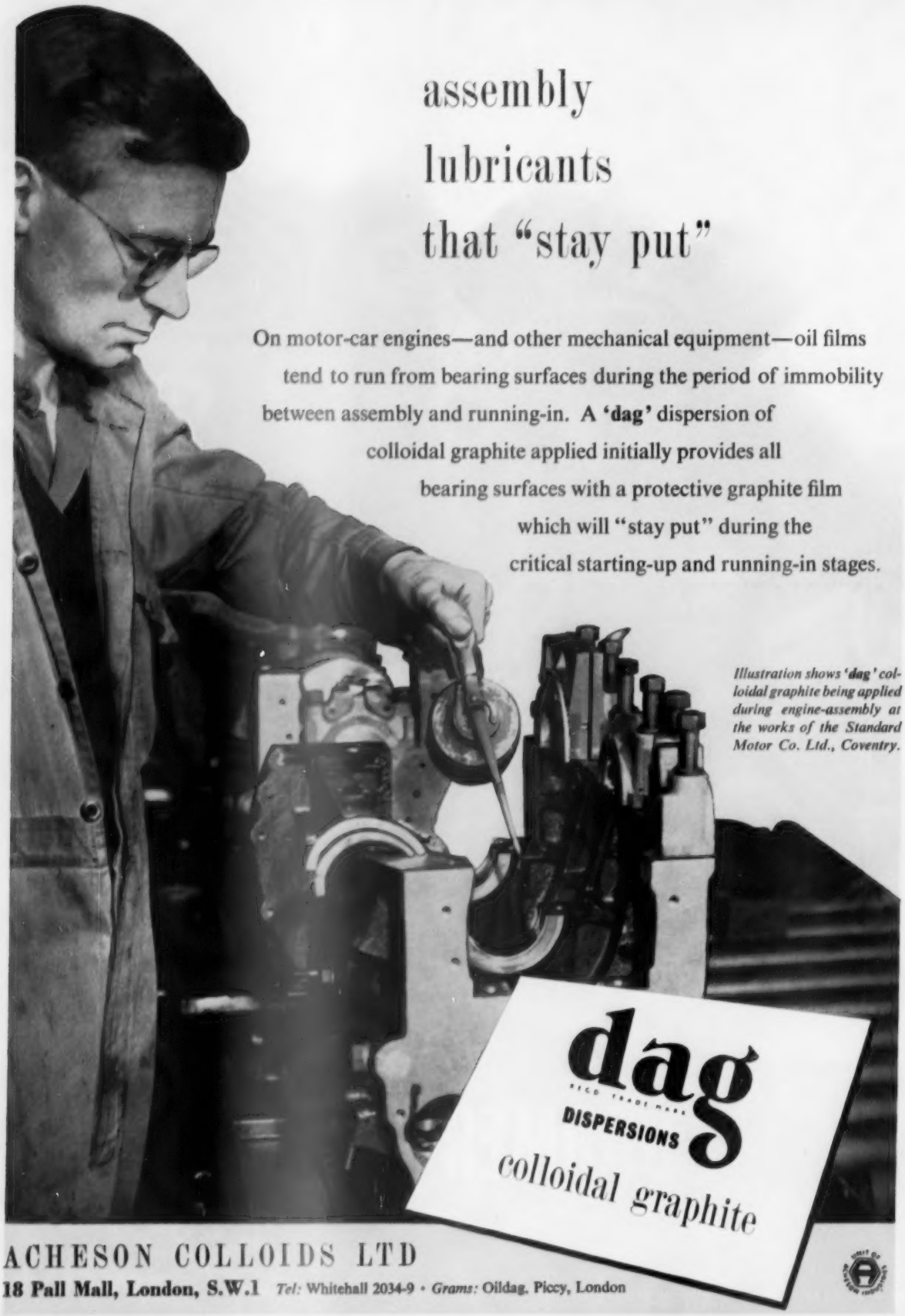

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Illustration shows ***'dag'*** *colloidal graphite being applied during engine-assembly at the works of the Standard Motor Co. Ltd., Coventry.*

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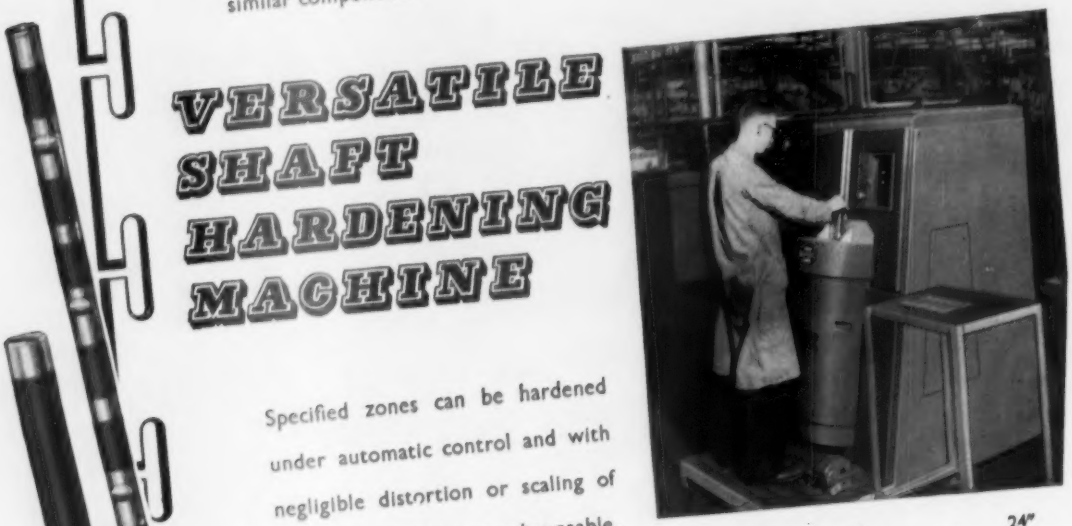
☆ The BIRLEC induction surface hardening machine illustrated here is a standard unit capable of handling a range of varied jobs. It is widely used by the automobile industry for the selective treatment of rocker shafts, selector rods and similar components.

VERSATILE SHAFT HARDENING MACHINE



Specified zones can be hardened under automatic control and with negligible distortion or scaling of the work. Quickly interchangeable, standardised control cams and inductors permit several different jobs to be run economically in successive batches.

Illustrated are typical induction hardened automobile rocker shafts and selector rod.

Maximum length of work	24"
Maximum diameter of work ...	1½"
Hardening zone selection	Cam
Maximum hardening speed ...	1½"/sec.
Maximum return stroke speed ...	6"/sec.
Typical production (12" stroke) ...	300/hr.
Typical operating cost ...	0.17d/piece.

Please send me Publication No. 78 on Shaft Hardening or further process details about .....

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WATTS Surface Finish Microscope

For examination of super-finished flat, spherical, cylindrical or concave workpieces. Image is repeatable, easily interpreted, requires no calculation or reference to tables. Magnification is X125 and it is possible to read irregularities to ·000001″

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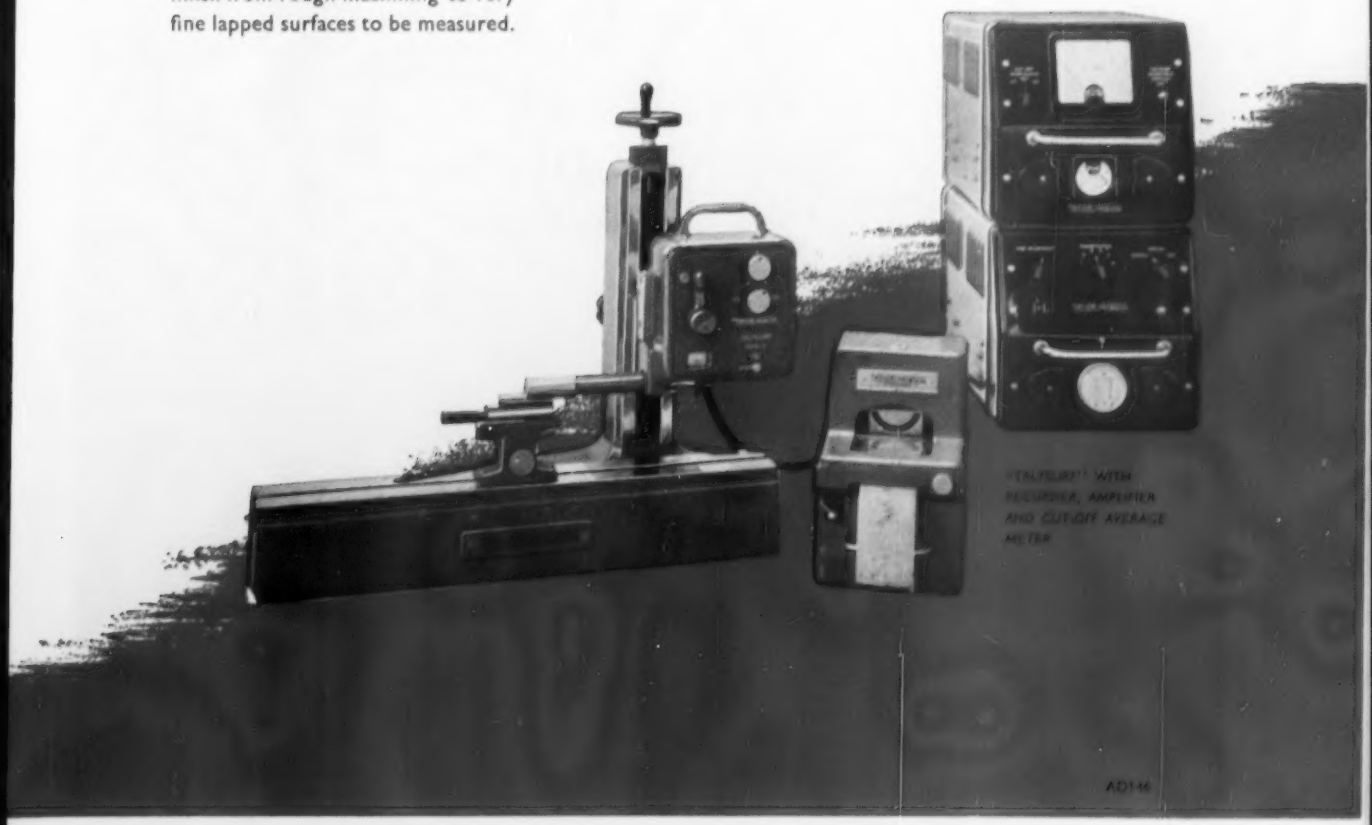
SIGMA Microtest Surface Finish Comparator

Electronic instrument for drawing across the surface by hand; ideal for surface testing at the machine. Four scale ranges, 0-5 to 25-100 micro inches to enable surface finish from rough machining to very fine lapped surfaces to be measured.



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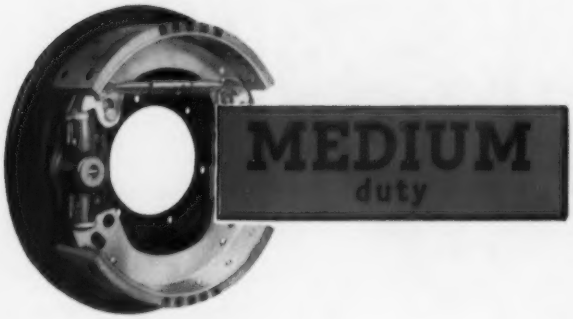

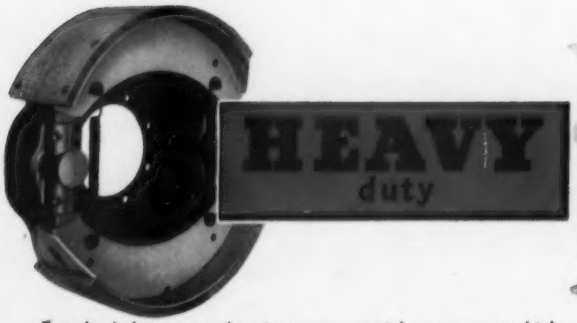

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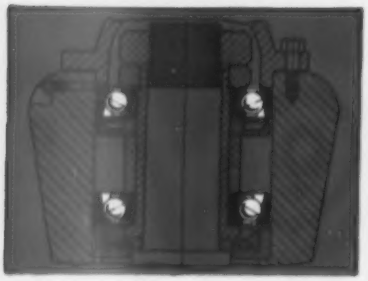

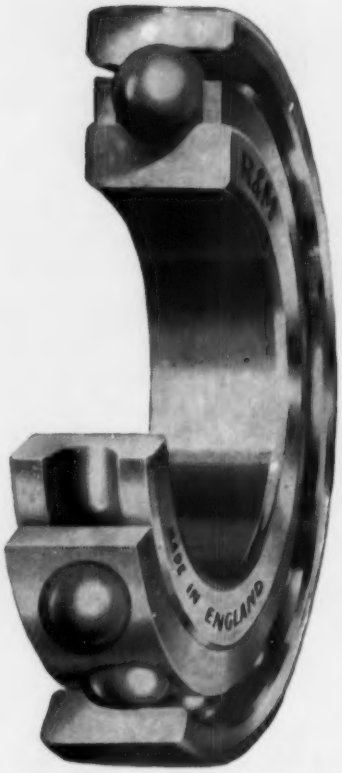

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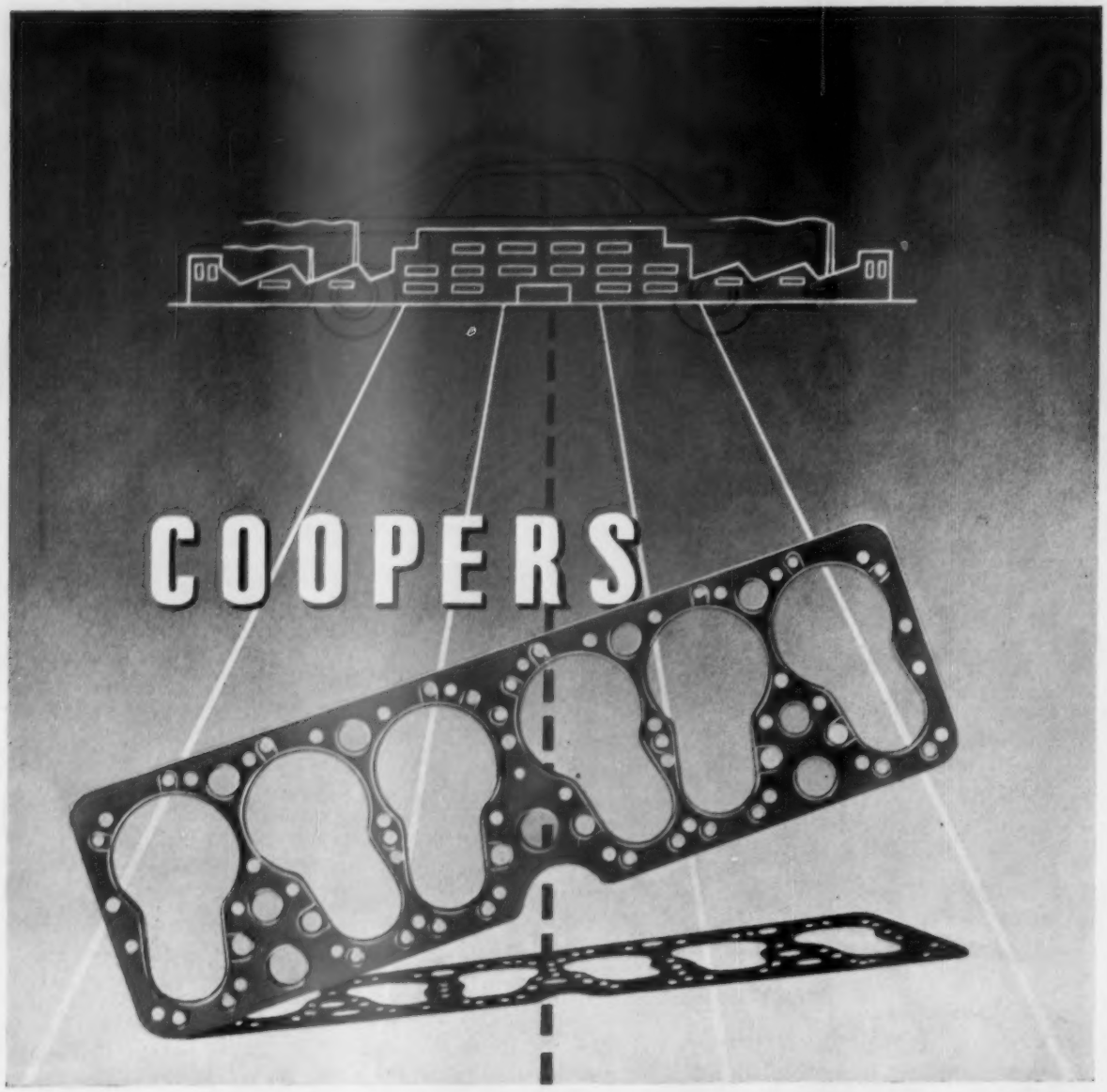

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Photograph by courtesy of Humber Ltd., Coventry

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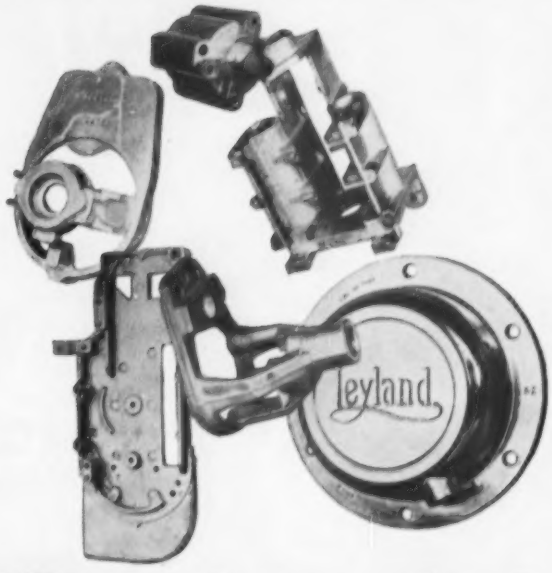

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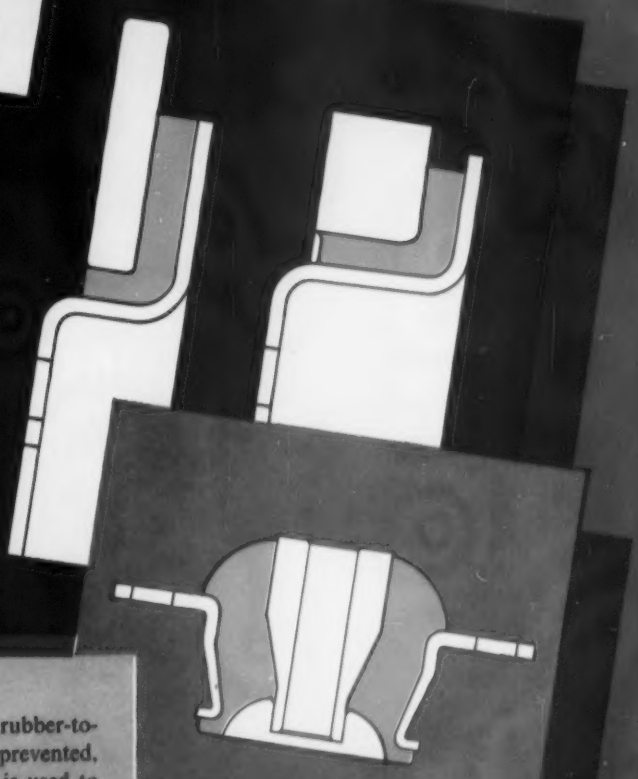
There is probably no component in the world which is so simple and yet so efficient in performing an important duty as the Metalastik torsional vibration damper. Its advantages are well-known, and they have been reached only by the unsurpassed skill of Metalastik in analysing the requirements of each engine, and then designing and manufacturing dampers to suit it.



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Here is another example of Metalastik success. With the rubber-to-metal weld to both the inner and outer sleeves, creep is prevented, and the formation of the sleeves is such that the rubber is used to the best advantage in compression as well as in shear.

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The high-duty shackle pin (shown alongside) was first evolved at the request of Leyland Motors Ltd., and has many millions of miles of service behind it on heavy vehicles—many bushes being replaced for further service after 400,000 miles.

The Ultra-Duty bush below is its younger brother for use on lighter buses and goods vehicles.

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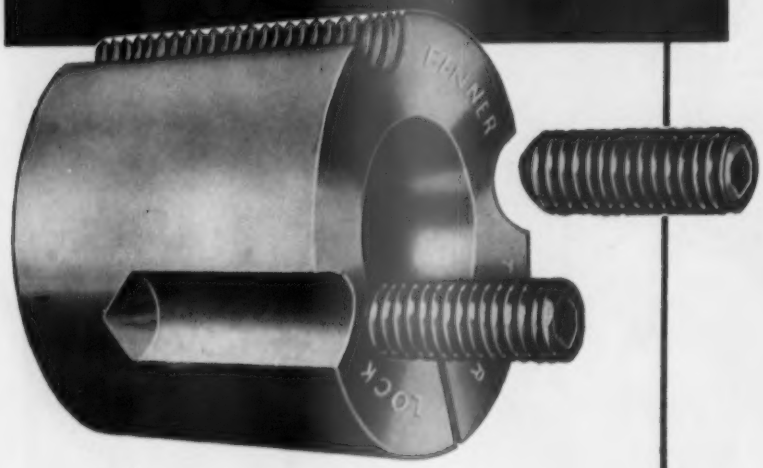
500,000 without a failure!



Taper-Lock has already revolutionised engineering practice. Fitting a pulley to a shaft no longer requires laborious key filing and 'trial and error' methods. Taper-Lock gives a vice-like grip simply by turning two screws.
Ask your nearest Fenner branch about Taper-Lock. A Fenner engineer will explain this 'one minute revolution' and how it applies not only to V-Belt Pulleys but also to chain sprockets, flexible couplings and weld-on hubs—with the same, interchangeable bushes.

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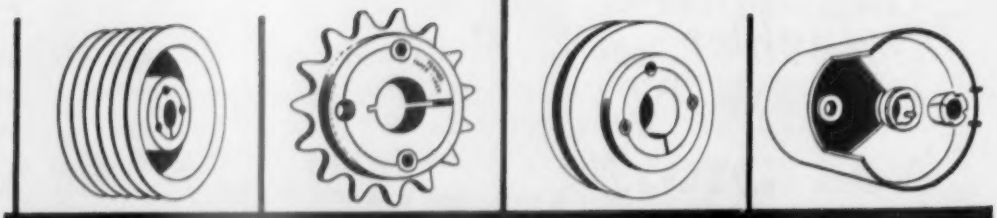

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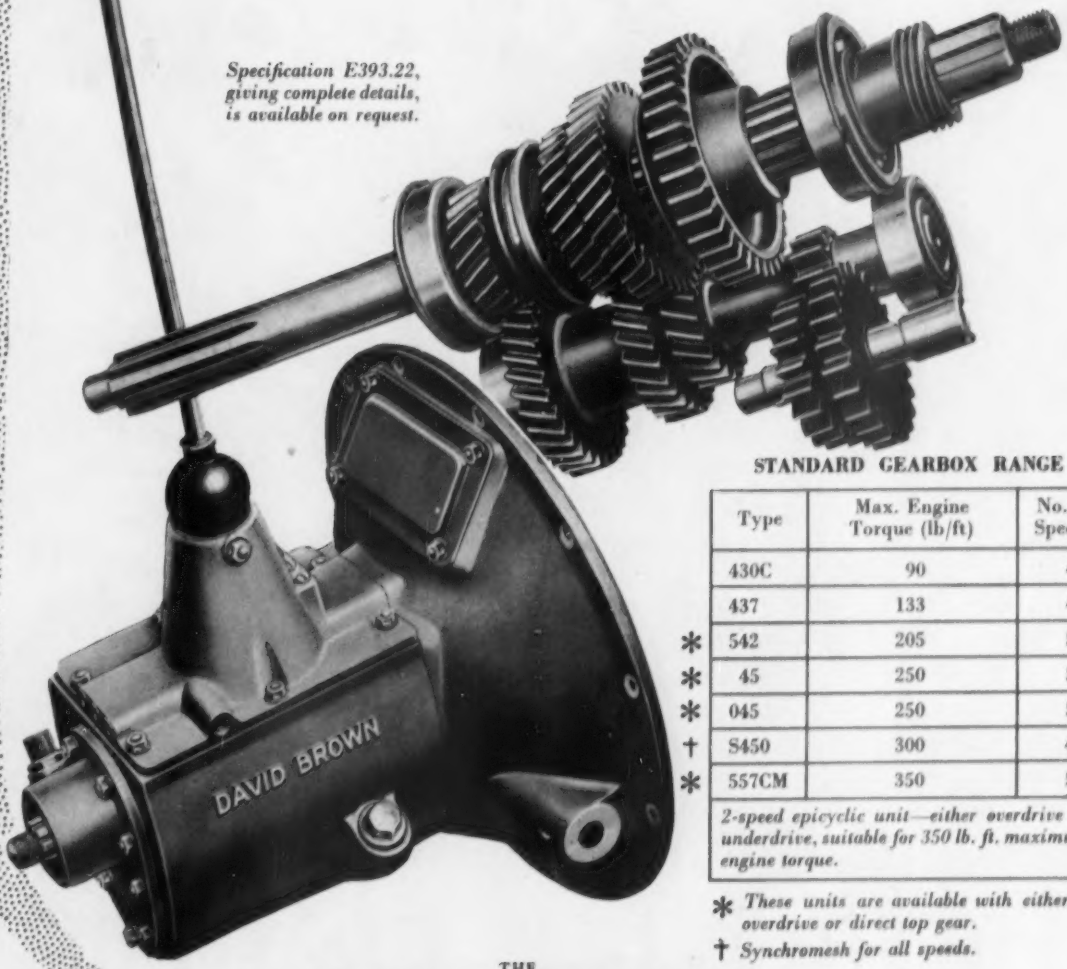
Outstanding features include quietness and ease of operation, simplicity, sturdiness, low weight to strength ratio and exceptionally short overall length. Here is a compact unit that will fit simply into chassis layouts within its range.

Specification E393.22, giving complete details, is available on request.



STANDARD GEARBOX RANGE

	Type	Max. Engine Torque (lb/ft)	No. of Speeds
	430C	90	4
	437	133	4
*	542	205	5
*	45	250	5
*	045	250	5
†	S450	300	4
*	557CM	350	5

2-speed epicyclic unit—either overdrive or underdrive, suitable for 350 lb. ft. maximum engine torque.

* *These units are available with either an overdrive or direct top gear.*

† *Synchromesh for all speeds.*

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
AUTOMOBILE GEARBOX DIVISION
PARK WORKS HUDDERSFIELD

. . . but for joining metals specify

METROVICK Electrodes

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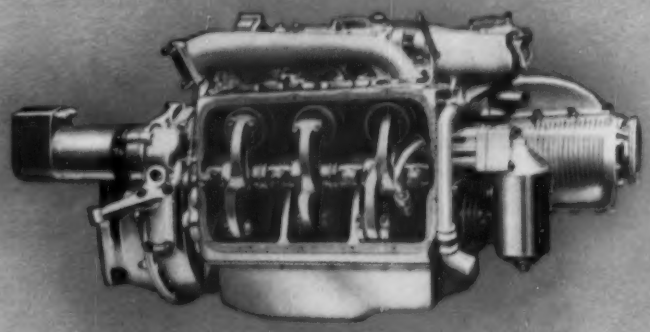
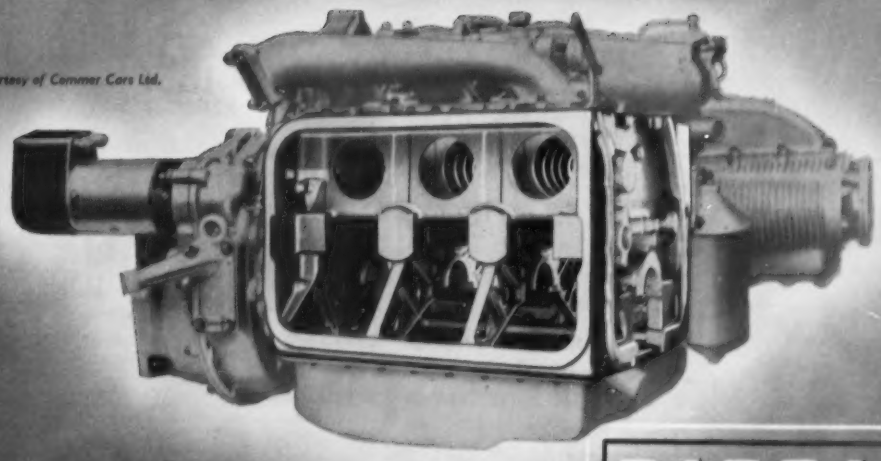


Highly mechanised methods are used for the rapid production of this cast iron Crankcase for the Commer T. S. 3. diesel power unit. In the unmachined state it weighs no more than 284 lbs. The design has eliminated masses of power wasting metal and has produced a lighter and more compact engine with greatly improved power weight ratio.

A FINE ENGINE built round A FINE CASTING

By courtesy of Commer Cars Ltd.



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DARTMOUTH AUTO CASTINGS LIMITED

Smethwick 40 Birmingham

High Duty Ironfounders

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The time taken by a driver to apply the brake after perceiving an emergency (usually between 0.4 to 0.7 of a second). Once the brake is applied, on vehicles fitted with the correct DON *quality, the stop is swift, smooth and safe.*

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HULL *52072*
IPSWICH *3023*
LEEDS 3 *20664/5*
LEICESTER *5260*
LEYTON *Leytonstone 0068*
LIVERPOOL *Royal 5202 and 1251*
MANCHESTER 3 *Blackfriars 0596*
MIDDLESBROUGH *44576*
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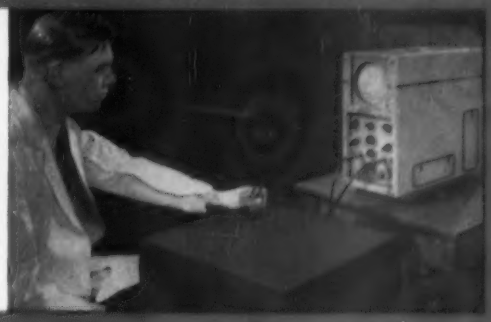

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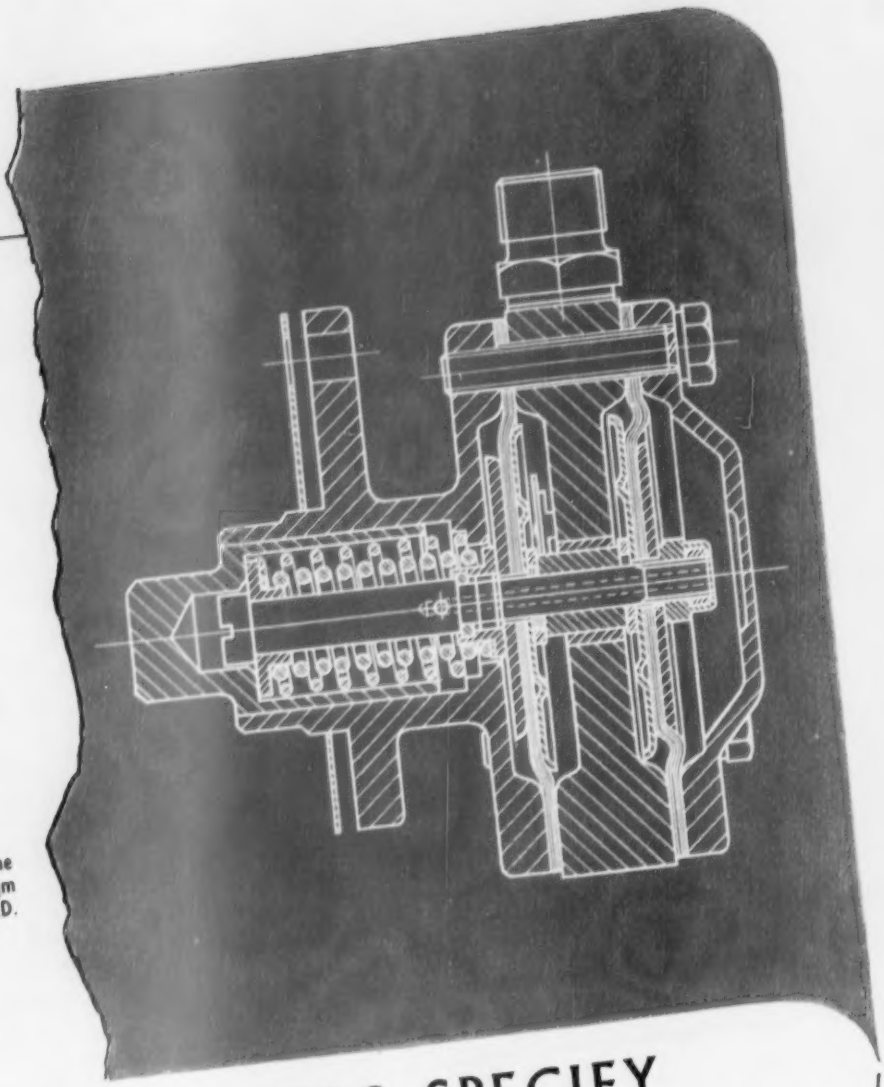

A sectional view of the Simms Double Diaphragm Feed Pump — type PLD.

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Simms

On high powered 6 and 8 cylinder Diesel engines up to 250 BHP, it is essential to have a feed pump which gives adequate fuel delivery. Consider these factors for the Simms PLD feed pump:

1. High output — up to 4 cubic centimetres at 1,000 RPM a stroke,
2. Double acting — for adequate output,
3. Double priming — for elimination of air locks,
4. Double diaphragm (2 banks of 4 diaphragms) — for strength,
5. Maximum fuel pressure automatically controlled — for steady delivery.

SIMMS MOTOR UNITS LIMITED

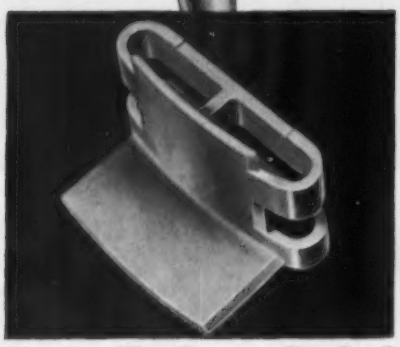
OAK LANE, EAST FINCHLEY, LONDON, N.2.

Telephone: FINchley 2262 (20 lines) Telegrams: Simotunit, Eastfinch, London

JSP/ST2

One 56 lb. and two 1 cwt. Birlec induction furnaces, for melting the nickel alloy used in the manufacture of the casting shown below—one of the side links of a Birlec heavy duty furnace conveyor belt. Photographs by courtesy of Samuel Osborn & Co., Ltd., Sheffield.

shell moulding



For shell moulding or investment casting capacities of 25 lb. and over, Birlec high frequency induction furnaces provide high quality metal of accurate analysis and with exact temperature control. For smaller outputs the Birlec Detroit I.C. (investment casting) furnace is similarly suitable.

Please send for further details given in leaflets Nos. 69 (high frequency induction) and 65 (Birlec Detroit).

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but there's much more to the automatic factory than clever electronics. Down at the business end things must be kept moving by smooth, faultless transmission of power.

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For a simple pulley or a complex machinery drive, call in Crofts for power transmission. Apply to us or to your nearest Crofts Branch for further details.

Conveyors with a new twist at Stewarts & Lloyds' Clydesdale Works—this Crofts variable speed skew roll is part of a system which carries hot steel tubes and continuously rotates them to ensure even cooling and straightness. The system incorporates hydraulic infinitely variable speed gears by Carter Gears Limited, a member of the Crofts group

Crofts

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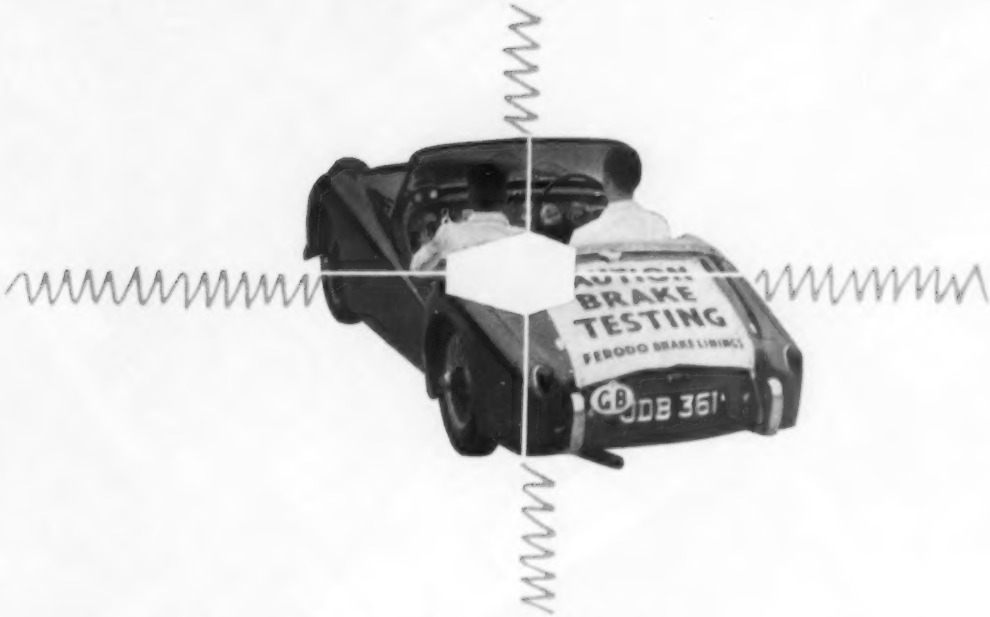
WE CAN MEET ALL POWER TRANSMISSION REQUIREMENTS UP TO THE LARGEST POWERS



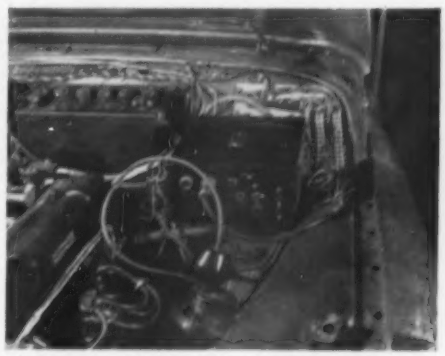
The car with a Built-in brain

This car of the Ferodo Test Fleet is packed with equipment to record and analyze brake performance. For, when arranging schedules for tests, Ferodo research workers must know what a brake lining is expected to do under practical conditions, and that is what these instruments tell them.

There is a high-speed multi-pen recorder which notes four parameters of brake performance: speed, deceleration, brake drum temperature and rate at which work is done at the brakes.

This information is collected electronically, and used by Ferodo to devise accurate, reliable testing schedules that help to produce brake linings highly resistant to fade and wear.

The electronic calculating unit installed in the boot of the TR.2.

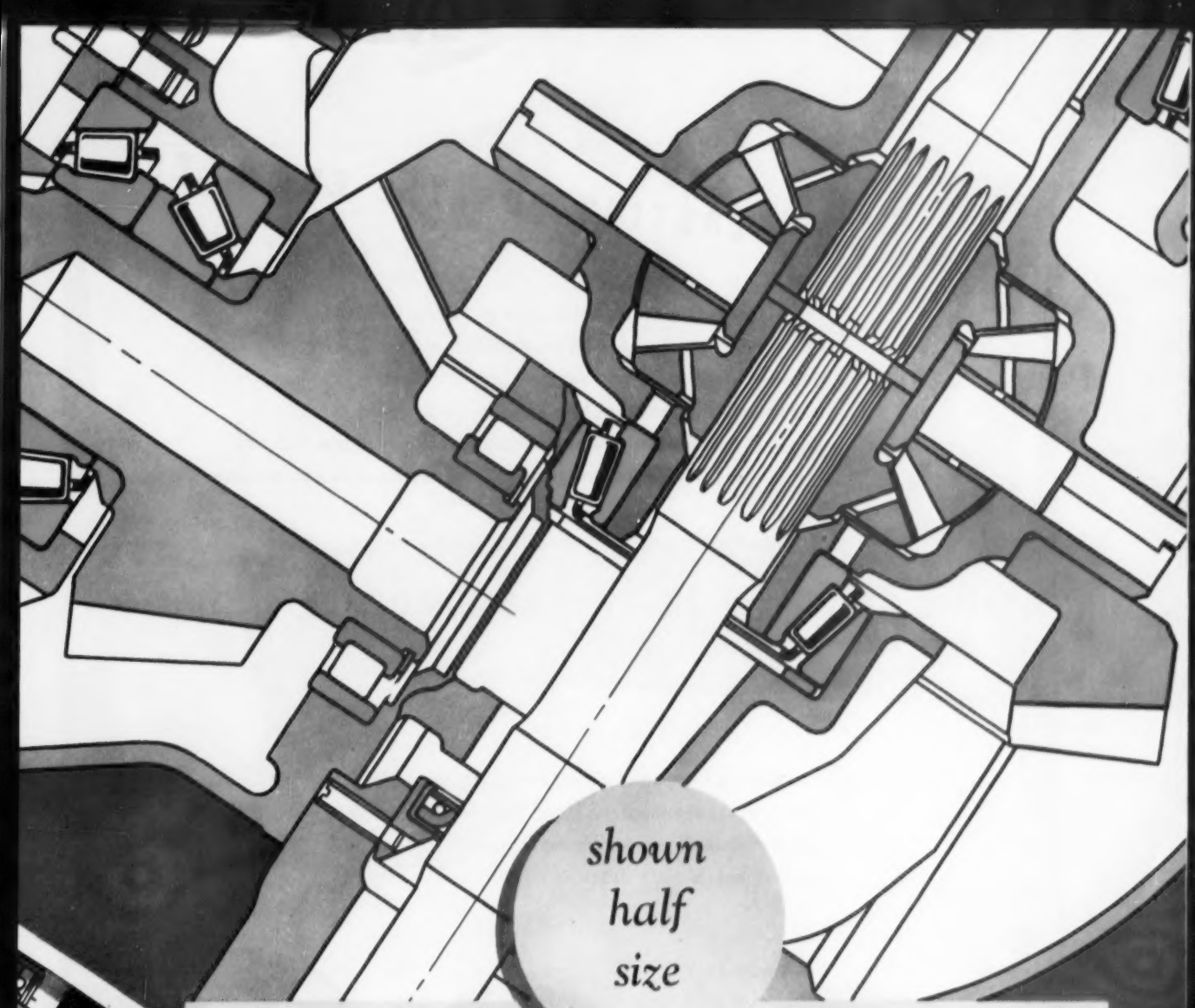


The power pack for the electronic apparatus, on the right of which may be seen some of the intricate cable connections.

FERODO

ANTI-FADE Brake Linings

FERODO LIMITED · CHAPEL-EN-LE-FRITH *A Member of the Turner & Newall Organisation*



shown half size

Three large rear axles

These illustrations show three interesting axles equipped with Timken tapered-roller bearings. Below, at left, the axle of the A.E.C. 'Reliance' and 'Monocoach'. The two other views relate to the Kirkstall 24-ton twin-axle bogie. In this, the drive is taken first to a ' third differential ' balancing the drive between the first and second axle. One sun wheel of this differential gear drives the hollow hypoid pinion of the first axle, the other drives a shaft passing through this pinion to a universal shaft at the rear of the first axle and driving the hypoid pinion of the second axle, each axle of course having its own differential.

Advantage is taken of the offset, characteristic of the hypoid drive, to take the sun wheel shaft over the axle shaft, giving a neat solution to an old problem.

The use of standard and steep-angle Timken bearings is self-explanatory.

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tapered-roller bearings

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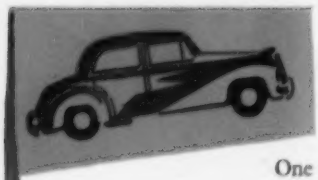
SUBSIDIARY COMPANIES: Fischer Bearings Company Ltd., Wolverhampton. Timken-Fischer Stockists Ltd., Birmingham

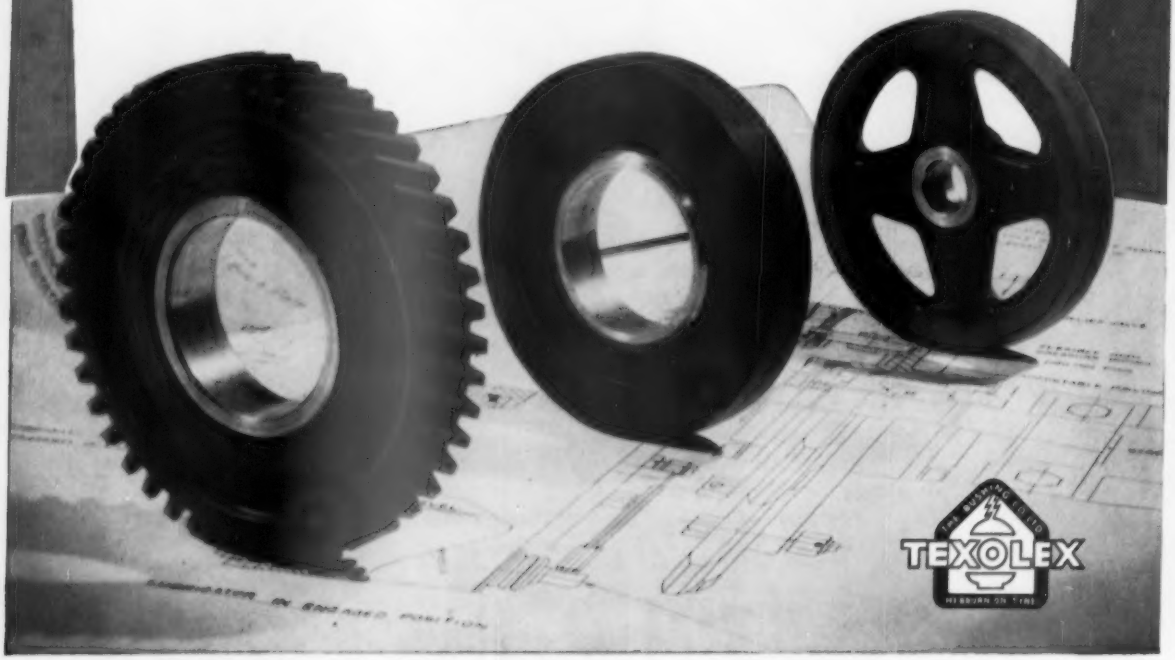


PLASTICS FOR THE ENGINEER

One of the many industrial applications of Texolex laminated mouldings is in the motor industry where extensive use is made of this material for cam gears. Some of the largest motor manufacturing organisations have found in Texolex many of the qualities of the ideal material, offering silence in operation, lightness in weight, high mechanical strength coupled with resistance to wear and corrosion.

TEXOLEX IN THE AUTOMOBILE INDUSTRY

The Bushing Company Limited, would be pleased to give further technical information about Texolex laminated fabric gears and their suitability and operation in camshaft, jackshaft and oil pump drives.



THE BUSHING COMPANY LIMITED · HEBBURN ON TYNE · ENGLAND

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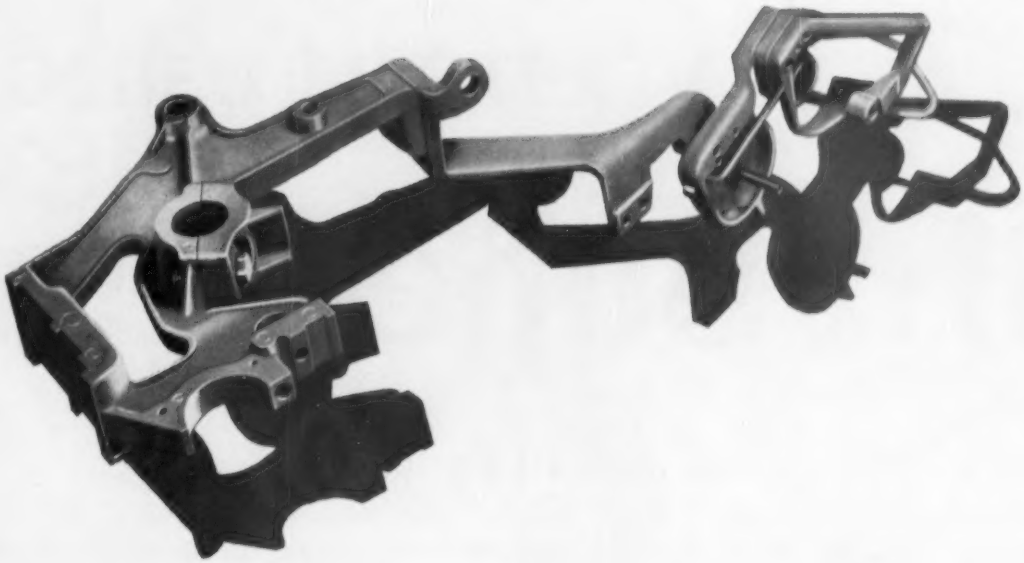
TODAY'S PROBLEMS IN INDUSTRY

Cutting Assembly Costs



One of industry's big production costs is the assembly of component parts. It's an important cost, expensive in time, in labour, and often in materials. In zinc die casting, however, an answer has been found that combines economy with quality production. Take the component part shown here, for example. It forms part of a cone winder used in cotton spinning and consists of six zinc die castings. So accurate were the die castings that no machining was needed, except for tapping holes used in bolting the parts together. That means a big saving in assembly time, in labour costs, in waste. However complicated the shape, zinc die castings have clean and accurate surfaces. Justifiably this process is claimed to be the shortest distance between raw material and finished product.

Write for list of members and publications describing the properties and uses of die castings to

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Now Stirling Moss answers motorists' questions:

Stirling Moss *won this year's Daily Express International Sports Car Race at Silverstone, Class 3,000 c.c. and over, using BP Super Plus, 100-octane petrol.*

BP SUPER PLUS IS 100-OCTANE — WHAT DOES THAT MEAN?

Moss : Octane number is a measure of the anti-knock quality of a petrol. At the top end of the octane scale is a substance called iso-octane; at the bottom end, a substance called normal heptane. 100-octane petrol has the same resistance to knock as 100% pure iso-octane.

CAN BP SUPER PLUS BE USED IN ANY CAR?

Moss : Yes — quite safely. BP Super Plus cannot possibly harm any engine. Of course, you would not get the full benefit from it unless you have an engine which really requires the extra octanes — for example if it has a high compression ratio. But try it by all means — especially if you run a sports car.

HAS BP SUPER BEEN CHANGED AT ALL?

Moss : No. It's just the same quality and just the same price. And it's still your best choice unless your engine is of a type able to take full advantage of the 100-octane fuel.

HAVE YOU CHANGED TO BP SUPER PLUS?

Moss : Yes. It was an obvious choice for sports car racing. And, although my touring car has always run very well on BP Super, it goes even better on this new juice. That's because I have fitted it with a special high-compression engine that can make full use of 100-octane petrol.

Now — a full range of BP petrols to cover every motoring need

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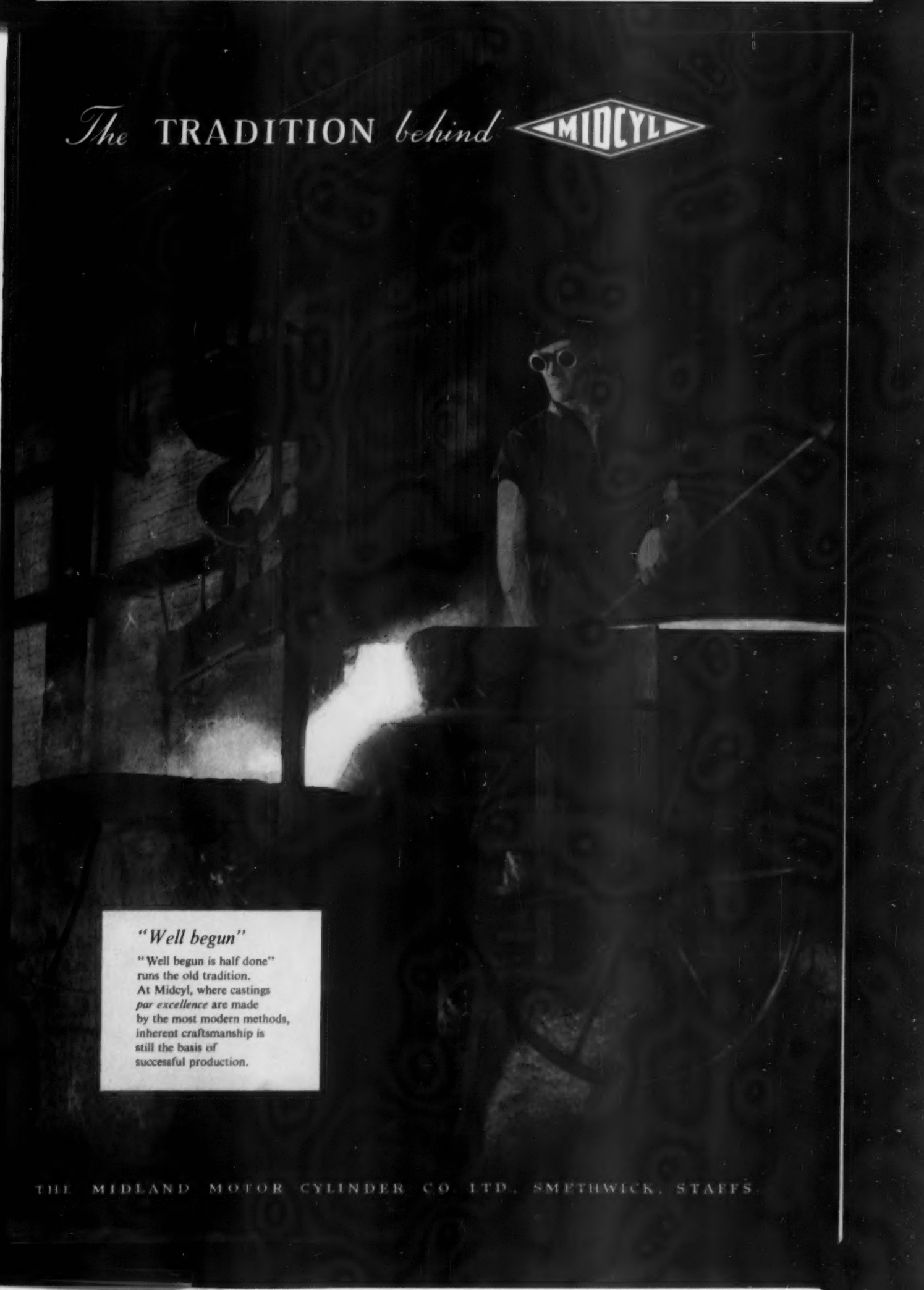
The TRADITION *behind* MIDCYL



"Well begun"

"Well begun is half done" runs the old tradition. At Midcyl, where castings *par excellence* are made by the most modern methods, inherent craftsmanship is still the basis of successful production.

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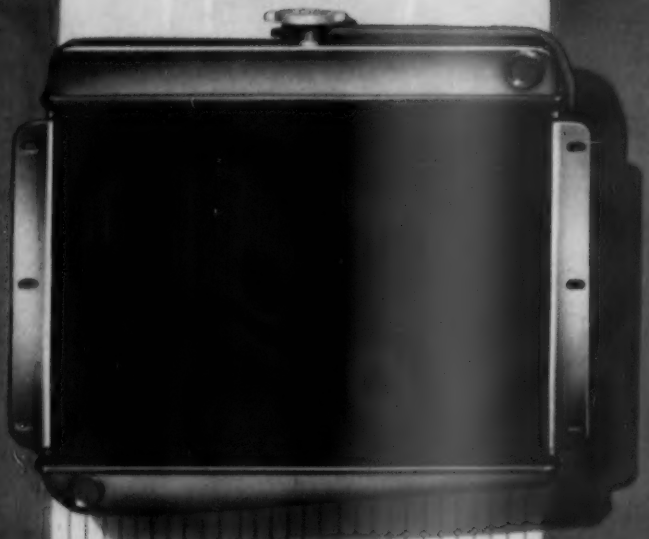

the Radiator design can be safely left to

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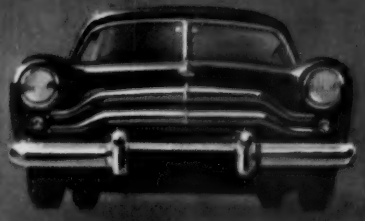

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38" SENSITIVES

Here is the baby of the range, showing its paces on a nickel chrome steel cylinder head. The International Harvester Co. Ltd., of Doncaster, find the spot facing and tapping of 8" × ¼" diameter holes reduced to child's play on the ARCHDALE 38". Jobs of this sort show the ease and speed of operation of these handy little machines to good advantage.

The 38" will drill up to 1" dia., in M.S. and has a spindle speed range of 129-1,627 R.P.M. Write for details.

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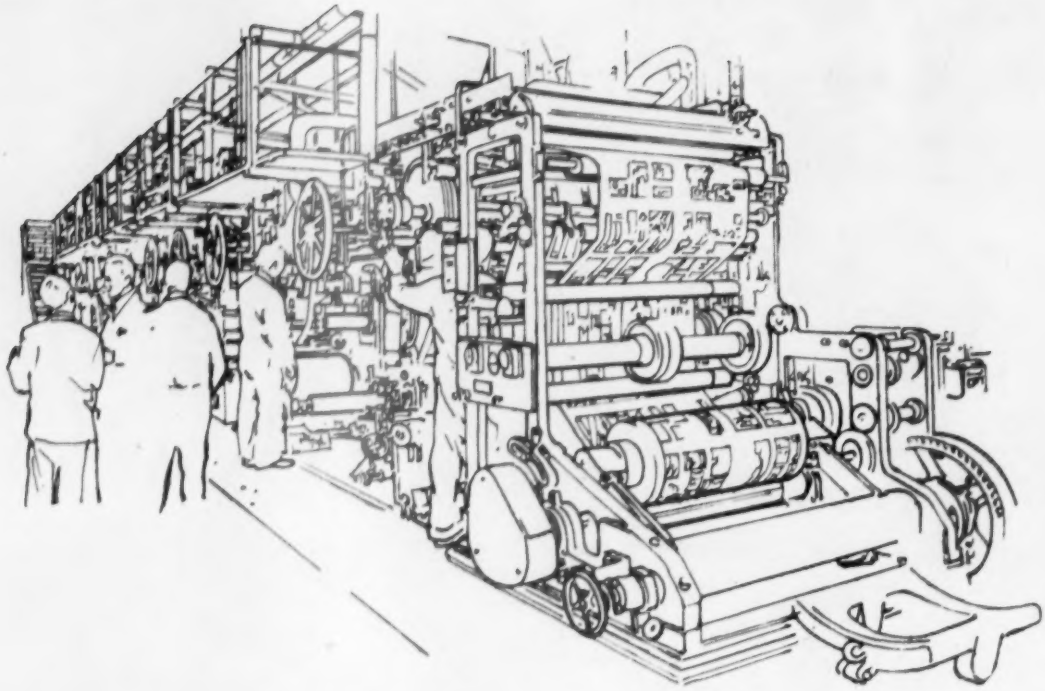
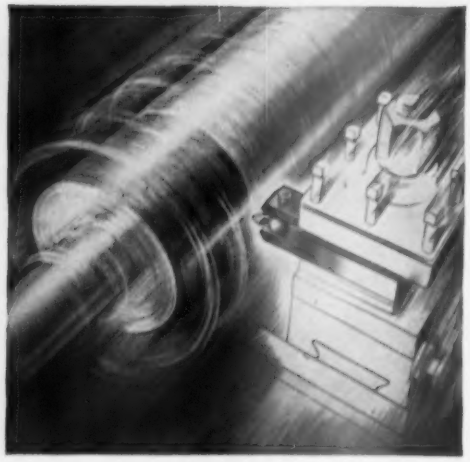


the printer's diamond



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THE STEEL COMPANY OF WALES LEADS BRITAIN'S GROWING STEEL PRODUCTION

Velindre Works is now operating

The new works at Velindre, near Swansea, is built on a site of 48 acres. It began operating on July 10th and will eventually double the Company's production of cold-reduced tinplate.

Velindre is similar to the tinplate works at Trostre, which was completed in 1951. Trostre is already producing at a rate of more than 400,000 tons per annum. The equipment at Velindre will be of 95% British manufacture and will include electrolytic tinning lines capable of producing all weights up to 1 lb. and differential coatings. The combined resources of the Company's plants will include five electrolytic tinning lines, 16 hot-dipped tinning pots, with automatic inspection and stacking and the widest range of size, substance and temper.

One of the new developments in steel technology planned for Velindre will be a continuous annealing plant. The first of its kind in Europe, it will speed production while maintaining traditional high standards of quality.

As the production of this plant increases, the necessity for further tinplate imports—which in 1955 totalled 80,000 tons—will disappear.

This latest addition to the plants operated by The Steel Company of Wales not only expands production but also increases the range of specifications available.

The Steel Company of Wales Ltd

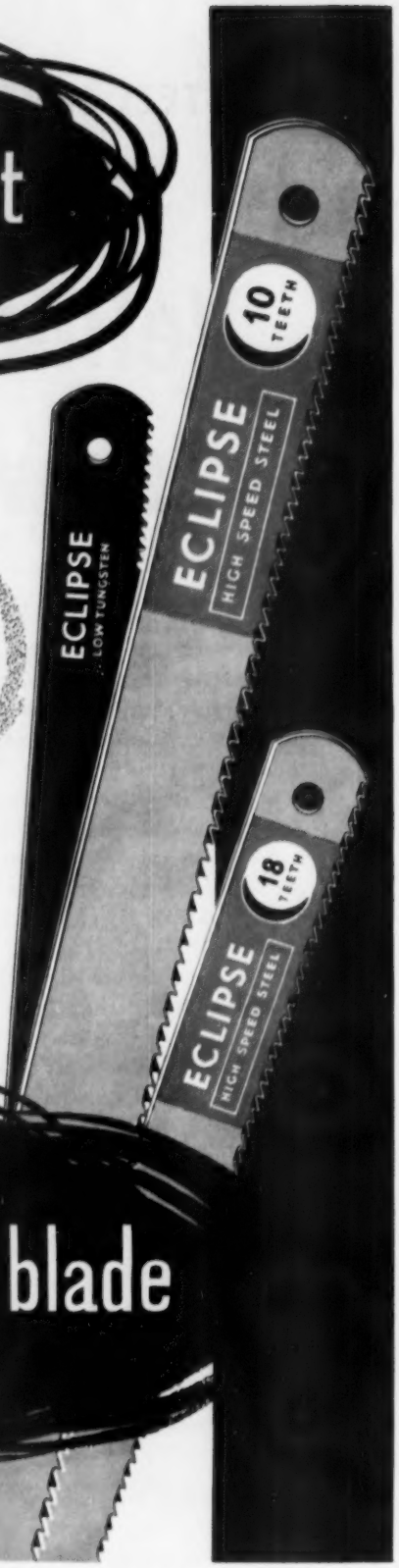
Tinplate enquiries should be addressed to
The Tinplate Sales Manager, The Steel Company of Wales Limited, Carmarthen Road, Swansea, Glamorgan.

better buy the best

better buy

Eclipse

the best hack saw blade



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AUTOMOBILE ENGINEER

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LUTON

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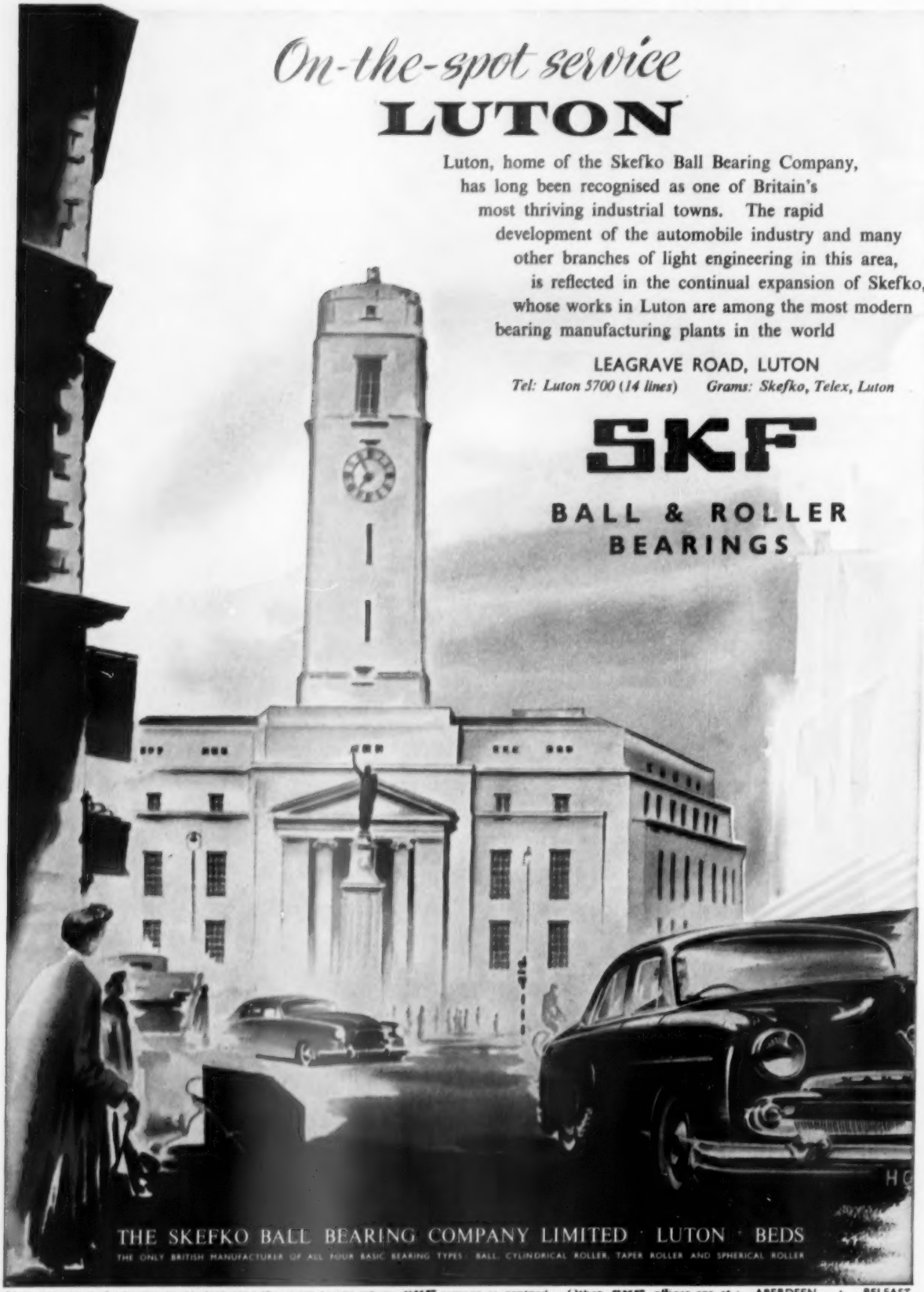

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F. C. Sheffield

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Commercial Vehicles

WHILE the passenger car industry is relatively in the doldrums, the commercial vehicle industry continues to prosper and to maintain the position it has won in export markets, despite increasingly keen competition from the Continent. There are also good grounds for optimism regarding the future, and we are certain that the forthcoming Commercial Motor Show will prove that British manufacturers are alive to the need for design developments if export markets are to be held.

The design of commercial vehicles for export must, of course, raise problems that would not be met, or would not have the same importance, if only the home market had to be considered. Vehicles must operate satisfactorily under conditions that may vary very widely as between one market and another, and which are far different from conditions in Britain. For instance, overseas operations generally entail longer hauls and over worse roads than are usually met with in this country. Because of this, riding comfort is a prime necessity.

In recent years great advances have been made in the design of public service vehicles and long distance coaches with a view to providing the highest possible standard of passenger comfort. The greatest care is now taken to minimise engine noise, to provide good suspension (some interesting new suspensions will be displayed at the Show) and to install the type of ventilation and heating best suited to the operating conditions.

For some years, emphasis was chiefly directed to improvements in passenger carrying vehicles, but more recently, thought has been given to crew comfort in goods carrying vehicles. This development is all the more welcome because it once looked as though the British industry was lagging behind their Continental competitors in cab design. Most manufacturers now realise that crew comfort is a most important matter and many modern vehicles leave little to be desired.

Two further points that could be of tremendous benefit to the drivers of heavy vehicles are two-pedal control and power assisted steering. Both developments are available in various forms, but at the moment all that can be said is that there is a trend towards their wider use. There is no doubt that power-assisted steering and a fully automatic gearbox would be great advantages for the buses used in the heavy traffic of towns and cities.

Although punctures are rare on heavy vehicles, when they do occur they can cause serious hold-ups and may create dangerous traffic conditions. Because of this, there is considerable interest in tubeless tyres for heavy vehicles. Work is going on in connection with such tyres, and in several quarters, but there are difficulties to be overcome before widespread use can be made of them.

Generally, supercharging seems to be reserved for special applications, but much greater use might be made of it. That it can afford appreciable advantages is unquestioned. The effect of supercharging on power output is too well known to call for any remarks here. There are, however, other advantages which are commonly overlooked.

For instance, a supercharged engine will give cleaner combustion than is obtained with a normally-aspirated engine. Therefore, there will be smaller deposits in the combustion chamber and on the piston crown. In consequence, there is less likelihood that carbon build-up will occur round the top land and cause top land drag, a condition that may lead to ring sticking or even piston seizure. Furthermore, as the combustion is cleaner and more complete, the carbon and sooty deposits in the combustion chamber are smaller, and there is reduced danger that these deposits will find their way to the crankcase and cause lubricant contamination.

The reduced amount of carbon formation in the combustion chamber means that there is less risk that carbon particles will break away from the head of the piston and become embedded in the valve seats. Valve pitting is considered by many to be a serious problem to-day, and at least one organization has observed that with a supercharged engine there is less pitting because the combustion is more complete and cleaner.

Finally, on this question of supercharging it may be pointed out it can help to abate smoky exhaust nuisance. There has been a good deal of alarmist speculation about the effect of exhaust smoke on the health of the populace. The fact is that diesel exhaust is no more dangerous than the exhaust from a petrol engine; that is, in the open the concentration of carbon monoxide is not significant. The diesel exhaust is, however, much more noticeable and is unpleasant. In general, it is the mechanical condition of the engine and the injector system that is the determining factor, but there is reason for thinking that even so, a supercharger can lead to improvement.

Automatic Transmissions

Notes on the Design and Manufacture of Borg-Warner Units

EVENTUALLY, and sooner rather than later, the range of British cars that can be supplied with automatic transmissions will have to be greatly increased. This, of course, means that automatic transmissions will be offered as optional extras for the less expensive cars. To what extent they will be used is mainly a matter of economics. That an automatic transmission is, and must for at least some considerable time remain, appreciably more costly than a conventional transmission is an inescapable fact. The economics of the matter will, however, be greatly improved by the production of Borg-Warner transmissions at the new factory recently opened by Borg-Warner Limited, at Letchworth, Herts.

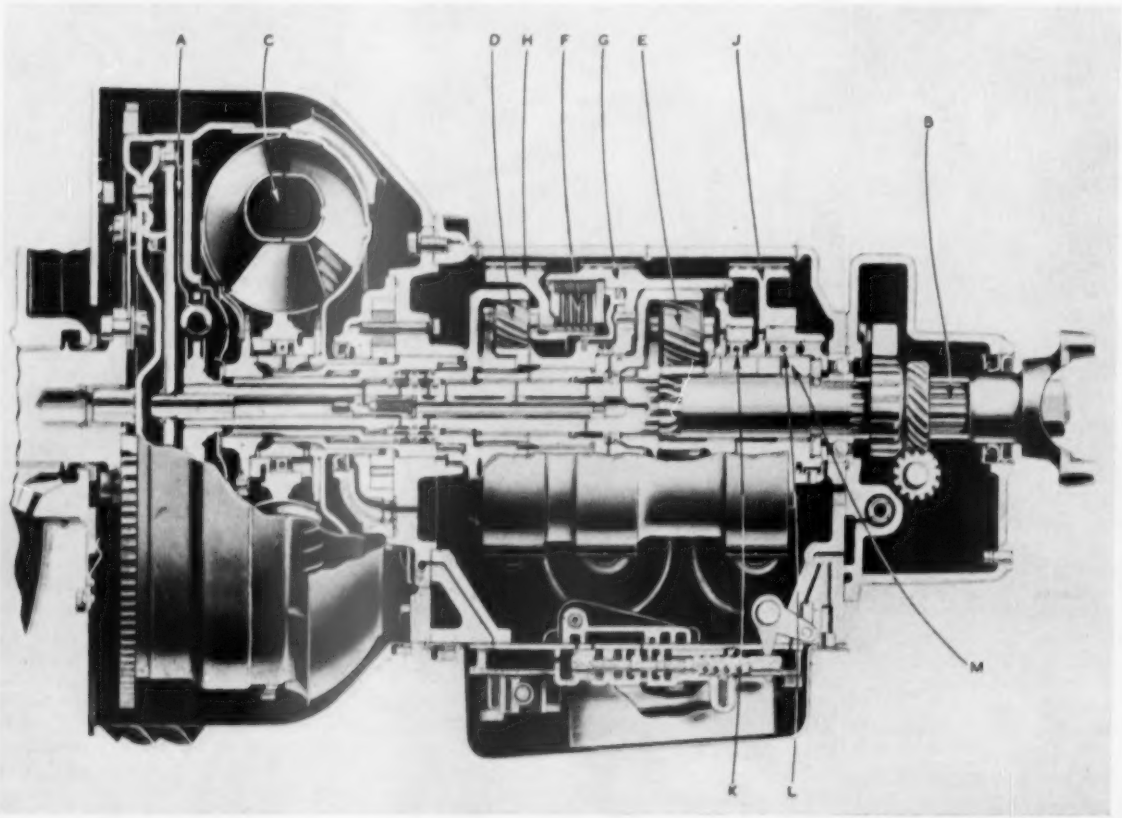
To begin with, the Borg-Warner transmission system has already been tried and proven in America and its manufacture in this country does not entail development troubles and expenses. Secondly, the knowledge and experience of the engineers of the parent company in the United States of America has been freely available to help in planning and equipping the new factory in a manner that will ensure that the high quality of work which is absolutely essential can be produced at the lowest possible cost.

Whereas an organisation undertaking de novo the manufacture of so complicated a mechanism as an automatic transmission would have had to solve a good many production problems, at Letchworth matters such as the right types of machines and the best operational sequences are based on practices that experience in America has shown to be most suitable. Nor has the parent company been satisfied merely to advise at a distance. Instead, key technicians have been sent from America to this country to teach and advise the personnel who will eventually have the responsibility of running the Letchworth factory. That it has been possible to adopt an established design and established production methods is, of course, economically important.

Volume of output is another factor of economic importance. For at least some time to come, the demand for automatic transmissions for any one make of car will not be sufficient to warrant any car manufacturer's undertaking their production. Borg-Warner Limited, however, can, and

Fig. 1. Section showing the mechanized construction of the Borg-Warner automatic transmission.

A—*single plate clutch*, **B**—*gearbox mainshaft*, **C**—*hydraulic torque converter*, **D**, **E**—*epicyclic systems in series*, **F**—*multi-disc clutch*, **G**—*low gear band*, **H**—*reverse gear band*, **J**—*forward gear band*, **K**, **L**—*free wheels*, **M**—*rear epicyclic sun gear*



do, look forward with confidence to supplying transmissions to a number of manufacturers. Admittedly, no two engine designs will call for transmissions with exactly similar characteristics; therefore, each transmission will be specially tailored to suit one specific engine design. Nevertheless, the greater part of the components that go to form a transmission will be common to all designs, and therefore the economic benefits of volume production will be obtained.

The transmission system

Nominally, the Borg-Warner automatic transmission gives three forward speeds, low, intermediate and high, and reverse. However, through the incorporation of a hydraulic torque converter coupling for use on low and intermediate gears, there is a smooth gradation from a maximum in the order of 4·6 : 1 on the low gear to a minimum in the order of 1·435 : 1 on the intermediate ratio. For high gear, a single-plate clutch couples the engine output direct to the transmission mainshaft; this gives a direct 1 : 1 ratio, and the torque converter and the gear system are by-passed. The torque converter has an output/input ratio ranging from 2·16 : 1 to 1 : 1.

The change from intermediate to high gear is made in a single step, but since this step is about the same as from third to fourth gear in a conventional four-speed box and appreciably less than the step from second to third in a three-speed box, it does not impose excessive loads on the direct drive clutch. Despite this, the direct drive clutch is always specially tailored to suit characteristics of the particular engine design with which the transmission is to be used. Reverse is obtained without extra gearing. The drive is reversed through the front epicyclic set and reduced to a 4·34 : 1 ratio in the rear epicyclic set.

The whole mechanism is hydraulically operated. Two pumps supply hydraulic pressure. One is located at the front of the gearbox and is driven direct from the engine. It therefore supplies pressure at all times when the engine is running. The second pump is at the rear of the box and is driven direct from the output shaft. It can supply pressure only when the vehicle is moving in a forward direction. A special valve unit controls the output from the pumps. This unit, in addition to acting as a relief valve, also causes the front pump to discharge freely when the output from the rear pump is sufficient to actuate the transmission, thus improving the mechanical efficiency of the system.

Control is effected through two valves : (*a*) a manually operated selector valve and (*b*) a centrifugally operated governor valve. The governor is coupled to the accelerator pedal linkage. The selector valve is coupled to a lever immediately in front of the steering wheel. This lever has five positions indicated by a pointer that moves over a quadrant marked P (park), N (neutral), D (drive), L (low) and R (reverse). As a safety measure, the ignition is wired in such a manner that the engine can be started only when the selector is in the P or N position. In the P position, a pawl engages with a gear on the mainshaft, which is therefore locked against rotation in either direction. This device will hold the vehicle stationary on the steepest gradient. In the N position the pawl is disengaged and the vehicle is free to move, but no drive is transmitted.

When the lever is in the D (drive) position, the operation of the transmission is fully automatic over the whole range. That is, gear changes up and down are made automatically in relation to the combination of vehicle speed and accelerator pedal position; the pedal position is, of course, indicative of the torque demand. If there is need for sustained engine braking, for example on a long descent, the lever may be moved to the L position at any speed below 40 m.p.h. and the transmission will then not automatically change out of low gear.

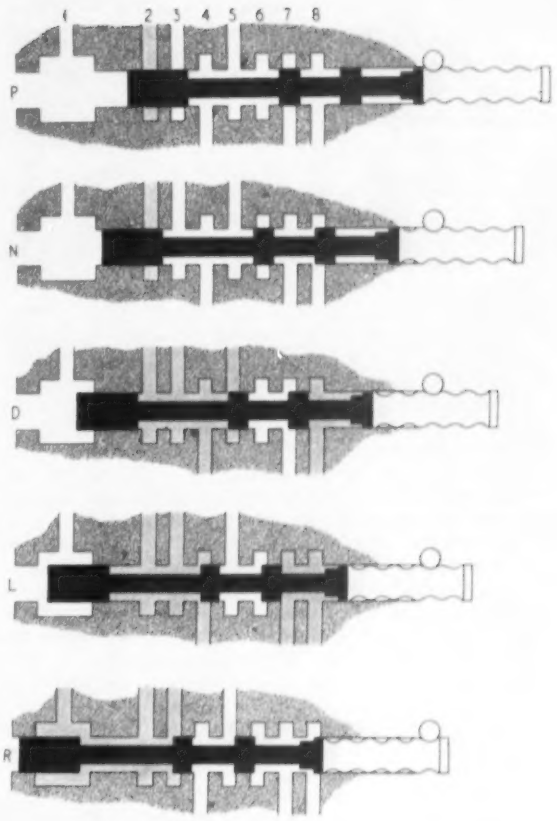


Fig. 2. The five positions of the selector valve

The mechanical construction of the transmission is shown in Fig. 1. There are the following major components.

(1) A single plate clutch, A, which under appropriate conditions transmits engine output direct to the gearbox mainshaft, B, and thence to the propeller shaft at 1 : 1 ratio.

(2) An hydraulic torque converter, C, which transmits engine output to the gear system, except when direct drive is engaged.

(3) Two epicyclic gear trains, D and E, in series.

(4) A multi-disc clutch, F, which can lock the front epicyclic train so that it rotates as a unit.

(5) Three brake bands, G, H and J, for reverse gear, low and forward drive respectively, and two freewheels, K and L, mounted on the sun gear, M, of the rear epicyclic unit.

The ring gear of the front epicyclic train is coupled direct to the driven member of the torque converter. It is therefore the driving member of the whole gear system. The planet carrier of the front unit is splined direct to the ring gear of the rear epicyclic train. It incorporates a brake drum, used for reverse, and the inner pick-up point of the multi-disc clutch. The front sun gear incorporates a brake drum for low gear and the outer pick-up point of the multi-disc clutch. An extension of this unit straddles the rear epicyclic and carries at its rear end the outer member of a freewheel that has its inner member mounted on the rear sun gear.

In operation, when the multi-disc clutch is engaged, the sun gear of the front train is locked to the planet carrier, and consequently the front epicyclic rotates as a unit, with the result that engine output is transmitted direct from the torque converter to the ring gear of the rear epicyclic at a 1 : 1 ratio.

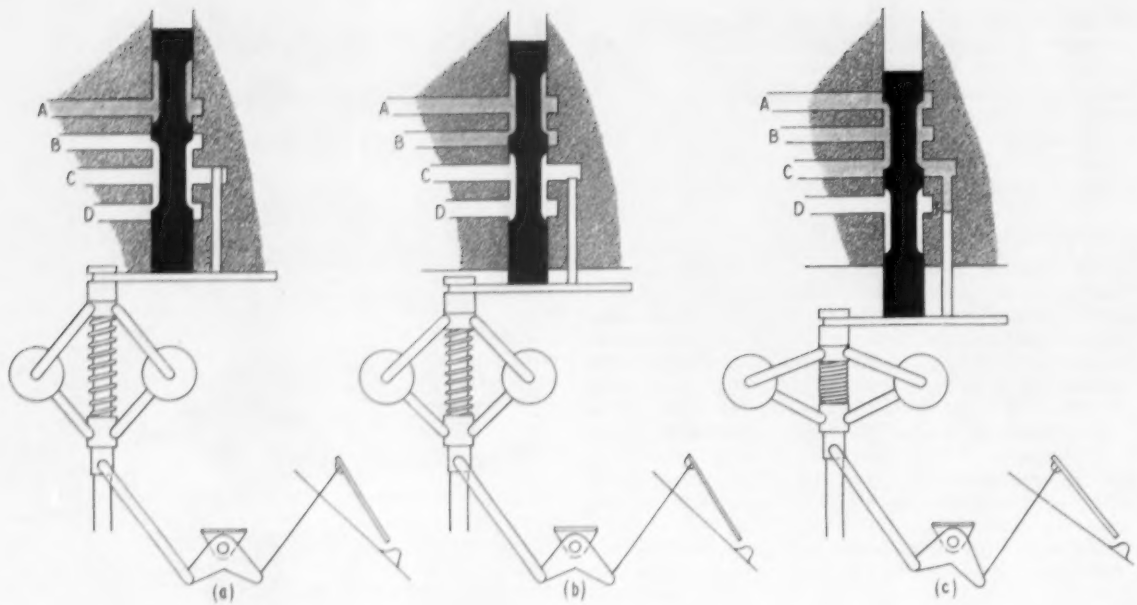


Fig. 3. Diagrammatic representation of the action of the governor valve

If the multi-disc clutch is disengaged and the sun gear of the front epicyclic is held by the low band, G, the planet carrier is driven at reduced speed and transmits power to the ring gear of the rear epicyclic at that reduced speed. When the multi-disc clutch is disengaged and the reverse band H is applied, the planet carrier is locked. Consequently, the sun gear is driven in the reverse direction at an increased speed and through the freewheel at the rear end it drives the sun gear of the rear epicyclic unit in the reverse direction at the increased speed.

Rear epicyclic train

The ring gear of the rear epicyclic is splined direct to the planet carrier of the front epicyclic, while the planet carrier is splined direct to the gearbox mainshaft to transmit the output from the epicyclic sets. The sun gear carries the inner member of the freewheel that has its outer member carried in the low drum and plate which form the extension of the front epicyclic sun gear. This freewheel is arranged to drive the rear sun gear in reverse direction when the front sun gear is also rotating in the reverse direction. A second freewheel on which the forward drum is mounted is carried by the rear sun gear. The drum is so arranged that when the band J is applied, the sun gear is locked against reverse rotation.

In forward operation, power is transmitted to the ring gear of the rear epicyclic unit either direct or at a reduced ratio according to requirements. Since the planet carrier is splined to the gearbox mainshaft, the sun gear tends to rotate in a reverse direction, but is prevented from so doing by the band J and its associated freewheel. The planet carrier is therefore driven forward at a reduced ratio. When the reverse band H is applied to the front epicyclic, it also locks the ring gear of the rear epicyclic; consequently when a reverse torque is applied to the sun gear, the planet carrier of the rear epicyclic is also driven in the reverse direction, and at a gear reduction that more than compensates for the step-up in the front epicyclic. The engagement and operation of the various units are summarised in Table I.

Hydraulic system

As was stated earlier, hydraulic pressure is supplied by two pumps, one located at the front end and the other at the rear end of the gearbox. The front pump is of the internal gear type. It is driven from the engine through the torque converter casing, and consequently supplies pressure

TABLE I. ENGAGEMENT AND OPERATION OF UNITS

		Gear			
		High (Direct)	**Inter-mediate**	**Low**	**Reverse**
Direct drive clutch		Engaged	Dis-engaged	Dis-engaged	Dis-engaged
Multi-disc clutch		Engaged	Engaged	Dis-engaged	Dis-engaged
Forward band		Applied	Applied	Applied	Free
Low band		Free	Free	Applied	Free
Reverse band		Free	Free	Free	Applied
Front epicyclic	Ring gear	As inter-mediate but runs free		DR	DR
	Planet carrier		Rotates as a unit	DN	0
	Sun gear			0	DN
	Ratio		1 : 1	1·610	1 : 1·64
Rear epicyclic	Ring gear	As inter-mediate but runs free		DR	DR	0
	Planet carrier			DN	DN	DN
	Sun gear			0	0	DR
	Ratio			1·435 : 1	1·435 : 1	3·30 : 1
Overall ratio (without converter reduction)		1 : 1	1·435 : 1	2·310 : 1	2·012 : 1

at all times that the engine is running. The rear pump is of normal gear type and is driven off the output shaft. It supplies pressure only when the vehicle is running in a forward direction. Output from each pump is led separately to a compound relief valve and thence via ball check valves to the control system. Primarily, the function of the compound relief valve is to regulate the hydraulic pressure, but it is so arranged that it also causes the front pump to discharge freely when the output from the rear pump is sufficient to meet all requirements.

Between the rear pump and the main relief valve there are passages which communicate with a parking pawl interlock and a reverse interlock. This arrangement effectively prevents "Park" or "Reverse" being engaged when there is any appreciable delivery from the rear pump; that is, when the vehicle is travelling forward at more than about three miles an hour. The main relief valve supplies pressure to two points only, namely, to the selector valve and to the converter shuttle valve. The function of the shuttle valve is to control the pressure in the converter. A lubrication valve permits oil to return to the gearbox for lubricating the mechanism; it also prevents the converter from draining when stationary.

The selector valve

Fig. 2 shows diagramatically the positions of the selector valve in relation to ports in the valve body corresponding to the five positions, P, N, D, L, R, of the selector lever. There are eight ports in all. For convenience of reference they are numbered 1 to 8 in the illustration.

Port No. 2 is the sole source of hydraulic supply to the control system. It will be seen from the illustration that in the P and N positions, the valve completely closes this port, so that the hydraulic system is out of action. Port No. 3 is open to hydraulic pressure at all times when port No. 2 is open. It leads to an accumulator piston.

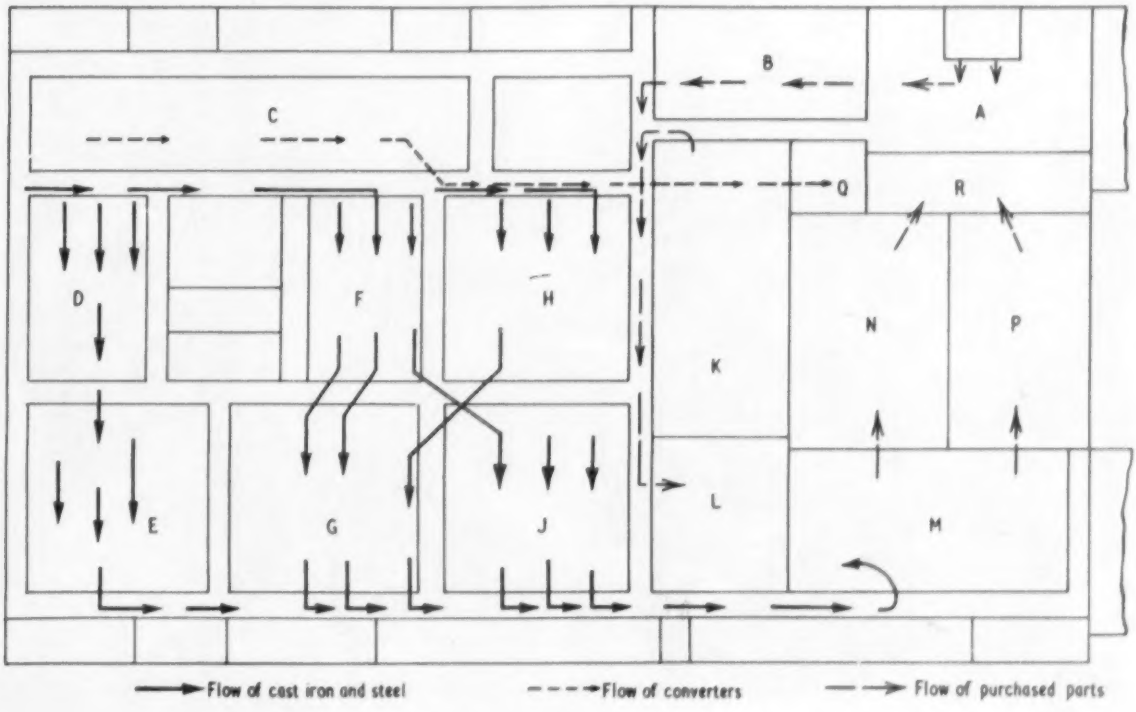
No. 4 port is open to pressure when the valve is in either the D or the L position. It supplies pressure to the forward band servo and to a relay valve that controls the low band servo. This port is also in direct connection with port No. 8. Pressure supply to the governor is effected through port No. 5, which is open only when the selector lever is in the D position, that is, only when the transmission is fully automatic. No. 6 port is a discharge port to the sump. It vents either port No. 5 or port No. 7 as required.

Port No. 7 leads to the low band relay valve piston and is supplied with pressure via port No. 8 when the selector valve is in the L position. It is vented via port No. 6 when the valve is in the D position. No. 1 port supplies pressure to the reverse band servo when the selector valve is in the R position; in all other valve positions, it vents the servo.

The function of the low band relay valve is to admit pressure from port No. 4 to the low band servo when the selector valve is in the L position, or when the vehicle is started from rest in low gear with the selector valve in the D position. In the latter case, the pressure is released when the change into intermediate gear occurs. This is effected by means of a connection to the passage in the governor circuit, which operates the multi-disc clutch. When the selector valve is in the D position, pressure from the governor circuit moves a spring-loaded floating member of the relay valve in such a way as to cut off the pressure supply to the low band servo and to vent that servo. On the other hand, when the selector valve is in the L position, pressure is fed via ports 7 and 8 to the opposite end of the floating member, which is thus held firmly in the position that allows pressure

Fig. 4. Layout of the production area

A—receiving and shipping bay, B—inspection bay, C—torque converter section, D—cast iron storage, E—cast iron machining, F—overdrive machining, G—heat treatment, H—automatic transmission machining, J—grinding section, K—non-productive stores, L—purchased parts stores, M—finished part stores, N—automatic transmission assembly, P—overdrive assembly, Q—static test, R—paletization area



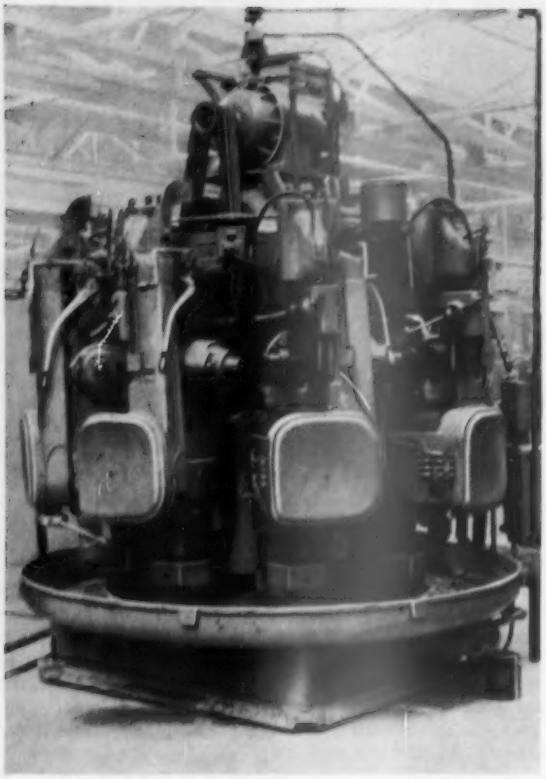


Fig. 5. Eight-station hobber for cutting three sets of splines on the mainshaft

to be supplied to the servo. The porting conditions are summarized in Table II; No. 2 port, since it is the source of supply, is not included.

The governor valve

The manner in which the governor valve functions is illustrated diagrammatically in Fig. 3, in which (*a*) represents the low, (*b*) the intermediate and (*c*) the high (direct drive) positions of the valve. There are four ports in the valve body:—

A—the pressure passage from the selector valve.

B—a passage to the multi-disc clutch with an extension to the low band relay valve.

C—a passage to the direct drive clutch.

D—a vent for pressure release.

As can be seen from the diagram, the valve itself is attached to one end of the centrifugal governor, while the other end of the governor is linked to the accelerator pedal. In effect, the governor forms a variable distance piece between the accelerator pedal and the valve. For a given pedal position, the effective length of the governor is reduced as speed increases; while conversely, at a constant speed the effective length increases as the accelerator pedal is depressed. Therefore, the actual position of the valve is determined by the combination of speed and torque demand.

At low speeds, or even at moderate speeds with the pedal hard down, the valve is in the position shown at (*a*) in Fig. 3.

TABLE II. PORT CONDITIONS FOR THE FIVE SELECTOR VALVE POSITIONS

Selector valve position	Ports under pressure	Ports dead or vented
P or N	none	all
D	3 4 5	1 6 7 8
L	3 4 7 8	1 5 6
R	1 3	4 5 6 7 8

In this position, pressure is admitted to the valve body via port A, but the other three ports are completely cut off. This is the low gear position. As speed increases, or if the

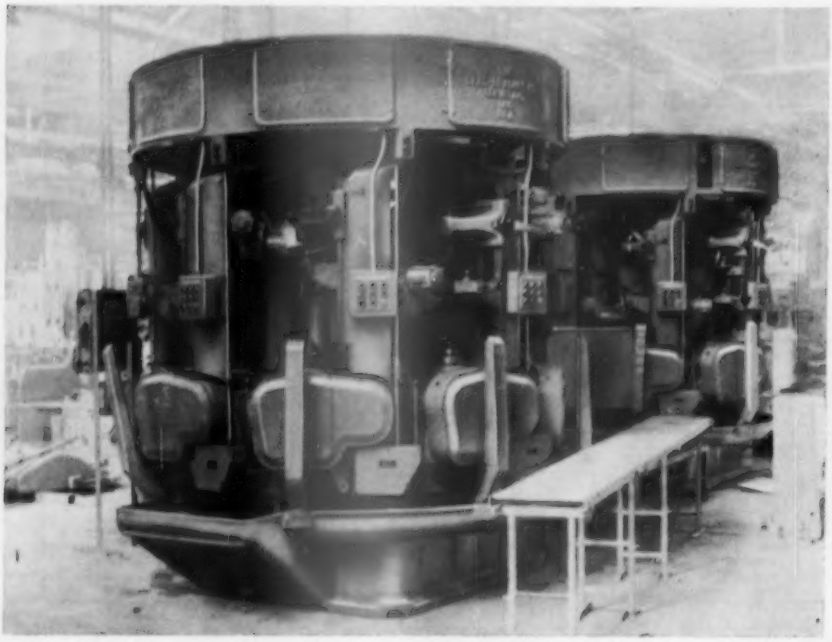


Fig. 6. On these eight-station machines the epicyclic ring gears are hobbed

speed remains constant but the accelerator pedal is released, the valve moves to the position shown at (*b*), thus opening port B and thereby leading to the engagement of intermediate gear. At further increase of speed, the valve is moved to position (*c*) to open port C to lead to engagemnet of the high gear (direct drive). As the vehicle speed decreases, or if the accelerator is depressed to maintain a constant speed, the valve moves upward, first closing port C from the pressure supply and venting it via port D, and eventually the same happens with port B.

A detent is fitted in the accelerator pedal linkage. It comes into effect at normal full throttle opening. If, however, full torque is required for a burst of acceleration or for speed on a severe gradient, the pedal can be "kicked down" past the normal full throttle position. This releases the direct drive clutch and, since the transmission remains conditioned for intermediate gear while it is in high (direct drive) gear, the lower ratio is engaged immediately the oil supply to the direct drive clutch is cut off.

Production facilities

The single-storey factory building, which is devoted solely to the manufacture of automatic transmissions and overdrives, has a productive floor area of almost 200,000 square feet. The layout is shown in Fig. 4. As can be seen from the illustration, great care has been taken to obtain flow production in an orderly sequence from raw material to final despatch. In general, raw materials are trucked from the receiving areas to the appropriate production areas in suitable stillages or tote boxes. Even the heaviest component produced in this factory can be handled manually without appreciable effort; therefore, there is no reason for elaborate mechanical handling equipment for inter-operation transfer, but for this purpose, considerable use is made of roller conveyors.

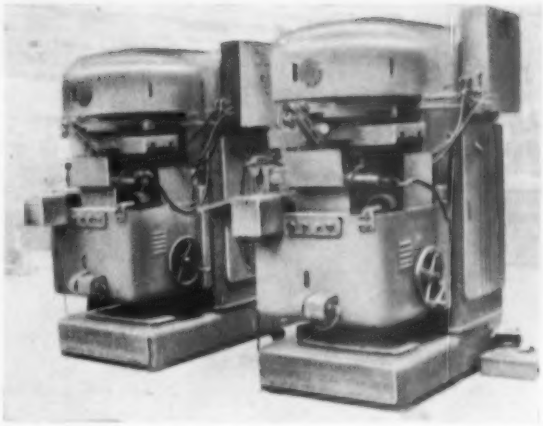


Fig. 7. Magazine feed shaving machines for finishing epicyclic gears

It is almost needless to say that the machine tools throughout the factory are of the highest standard, both for precision and output. The precision is necessary because very close tolerances must be maintained on most of the components. In general the components are not such as lend themselves to machining on automatic in-line transfer machines, a technique that is applied only to the main casing and the extension casing. Considerable use is, however, made of standard multi-station rotary indexing machines. For example, much of the gear cutting is carried out on eight-station hobbing machines of the type shown in Fig. 5. The components finished on these machines are generally finished

Fig. 8. The faces of automatic transmission casings are machined on drum mills

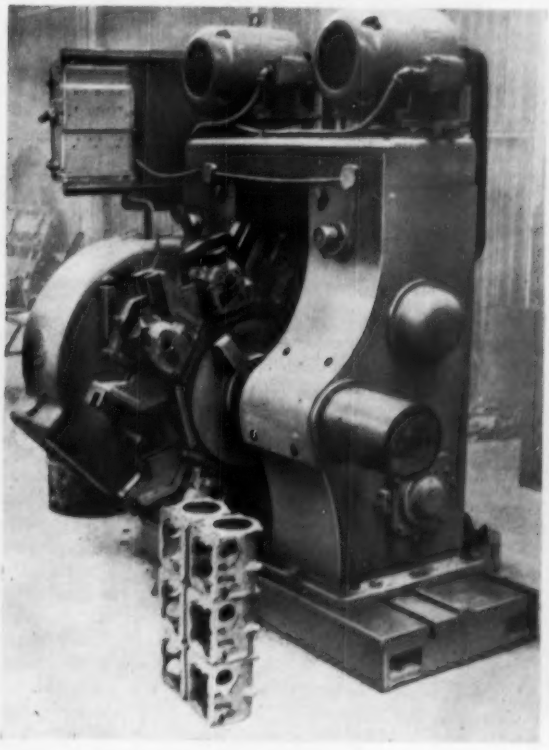
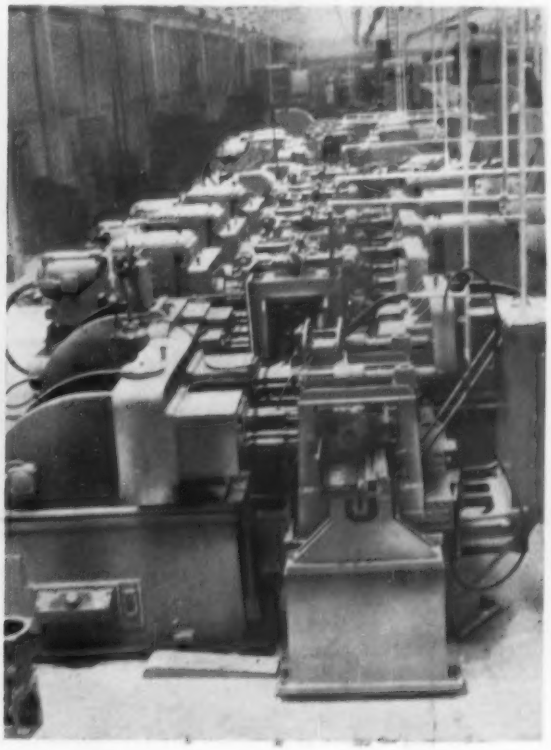


Fig. 9. The transfer machine line for Borg-Warner automatic transmission casings



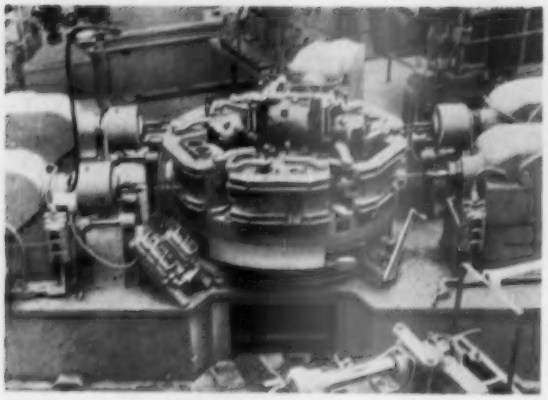


Fig. 10. A rotary indexing machine for drilling angular holes in the casing

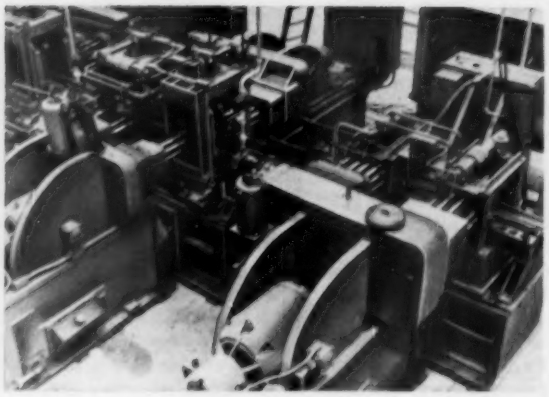


Fig. 11. The roll-over station in one of the in-line transfer machines for transmission casings

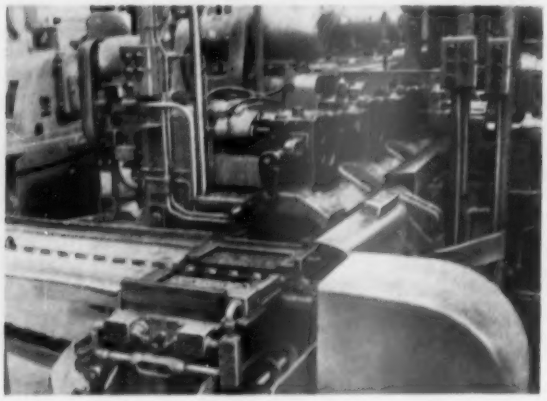


Fig. 12. In-line transfer machine for extension casings. Components pass through twice

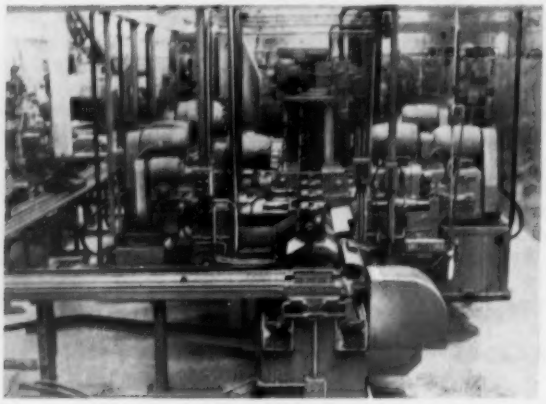
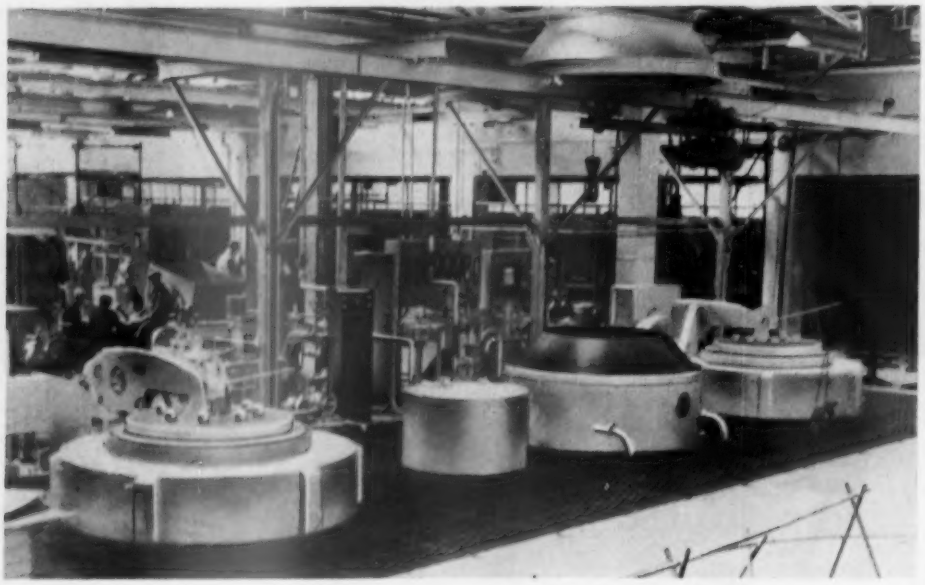


Fig. 13. Work fixtures for the extension casing are returned by the conveyor shown in this illustration

Fig. 14. Birlec pit-type furnaces in the heat treatment section



by shaving on machines which are magazine loaded and have full automatic cycles, see Fig. 6. Hobbing machines are also used for cutting splines on the mainshaft, see Fig. 7.

It is not intended to describe the manufacture of any one component in detail, but to confine these notes to brief references to certain machines used in the production of main and extension casings. At the first operation on the main casing, the bottom face is ground, and following this the ends and sides are milled on two drum mills, one of which is shown in Fig. 8. All the necessary drillings and tappings on this component is carried out on a machine line, which comprises a six-station in line transfer machine, a five-station horizontal rotary indexing machine for angular holes, an eight-station in-line transfer machine, a roll-over device which turns the component through 90 deg, and a two-station in-line transfer machine. Figs 9, 10 and 11 show these machines.

In the main transmission casing there are several holes which must be bored to close tolerances and to close dimensional relationship with other elements. Heald or Ex-Cell-O boring machines are used, in certain instances with multiple tooling to allow several bores and faces to be machined at one setting. This not only leads to a saving in labour costs, but even more important, it leads to greater accuracy.

An interesting operational sequence is carried out on the extension casing. For this, a Cross ten-station in-line automatic transfer machine is used. On this machine, which is shown in Figs. 12 and 13, the transfer rail carries a series of jigs. The component is loaded into a jig and passes through the machine for operations on two opposed faces. At the end of the machine, the transfer rail turns through 90 deg and carries the work along until it is clear of the heads on one side. At this point another turn through 90 deg is made and the work is carried along towards the loading end of the machine. Before the loading end is reached, the work is taken from the jig and two minor operations are carried out on machines immediately adjacent. The component is then reloaded on the the jig but in a different position. The transfer mechanism then carries the loaded jig round to the first station and thence through the machine again, but with two fresh faces offered to the tools. Incidentally, for all the in-line transfer machines there are special tool-setting gauges to facilitate tool changes.

Heat treatment

The heat treatment department is located within the production area in such a position that the flow sequence is not broken. Needless to say, heat treatment is a matter of fundamental importance in the production of both automatic transmissions and overdrives. Because of this, very careful consideration has been given to the type of equipment that is installed. Briefly, the equipment in this section comprises:—

Two Birlec pit-type furnaces with radiant tube heating, see Fig. 14. A large quenching tank is installed between the furnaces. These furnaces are mainly used for gas carburising overdrive output shafts. Three Birlec batch-type furnaces with integral quench tanks. They can be used for gas carburizing, carbo-nitriding, annealing and bright hardening. Planet pins, pinions, and brake drum hubs are among the components treated in these furnaces.

One rotary Holcroft furnace with continuous quenching. This furnace can also be used for gas carburising, and carbo-nitriding. It is used chiefly for treating automatic transmission gears.

These furnaces all employ an endothermic atmosphere supplied from four generators, two of 1200 and two of 250 ft³ capacity. It is interesting that in contradistinction to general practice in this country, which is to crack town gas to provide the furnace atmosphere, Borg-Warner crack propane, because they consider it gives better and more consistent results. All parts that are treated in the foregoing furnaces are cleaned in a Dawson steam washer before before treatment.

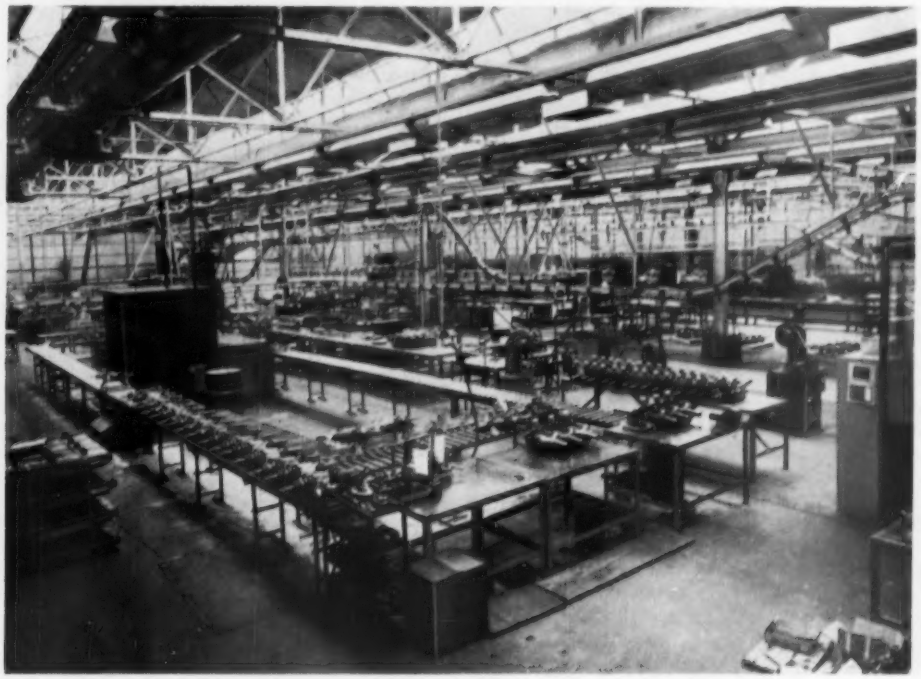


Fig. 15. The assembly area at the Borg-Warner factory is air conditioned and pressurized to ensure the highest possible standard of cleanliness

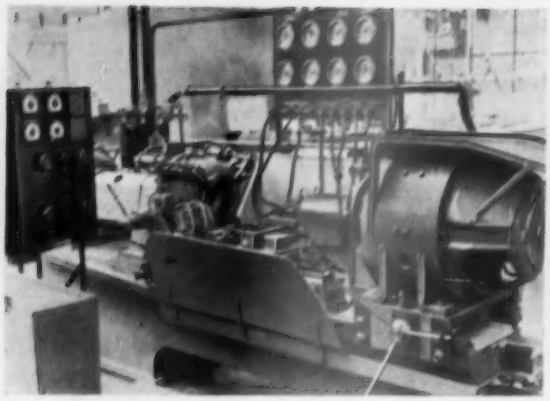


Fig. 16. Every Borg-Warner automatic transmission is dynamometer tested

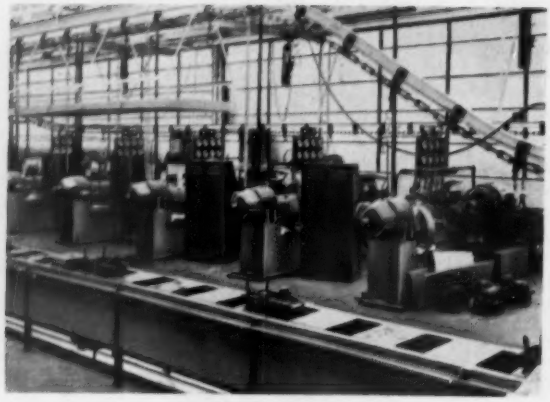


Fig. 17. There are five test dynamometers, each capable of handling 80–90 transmissions per day

In addition to the equipment mentioned above, the heat treatment section includes a Holcroft continuous low temperature tempering furnace of the tray type. This furnace has an integral washer through which the work passes before entering the furnace proper. There is also a Birlec continuous mesh belt tempering furnace. Work for this, passes through a Curran washer before it enters the furnace.

For certain components, induction hardening is the most suitable form of heat treatment, as regards both product quality and manufacturing economy. Therefore, two Wild-Barfield and one English Electric induction hardening machines are installed in the heat treatment section. Both Wild-Barfield machines have three stations. On one of these machines, two stations are used for selective hardening on mainshafts for automatic transmissions; the third station is tooled for the treatment of sun gears. Two stations on the second Wild-Barfield machine are used for hardening planet pins, while the third is used for tempering one end of the previously furnace-hardened governor control valve. The English Electric machine is used for overdrive parts. Any components that require tempering after induction hardening pass straight to a Holcroft mesh belt draw furnace. The heat treatment equipment also includes a cyanide installation for overdrive parts and a Wild-Barfield mesh belt brazing furnace.

Finished components are delivered to the finished parts stores, where they are held until they are required in the assembly section. Transfer from the production area to the stores is by trucking, but from the stores to the assembly area it is by closed circuit overhead conveyor. As the automatic transmission is an hydraulic unit, scrupulous cleanliness is absolutely essential. To ensure that all the parts are clean when they reach the assembly department, they pass through a steam pressure washer before they reach the assembly department. Furthermore, special precautions have been taken to give dust-free conditions in the assembly department. For instance, it is pressurised so that the differential between the normal atmospheric pressure outside the department and the slightly higher pressure inside will prevent the entry of any dust laden air.

In the assembly department, which is shown in Fig. 15, short sub-assembly benches run at right angles to a series of assembly conveyors. The benches are so arranged that the sub-assembly is completed at a point adjacent to the assembly conveyor station at which it is required. In the course of assembly, various checks are carried out, and finally the complete automatic transmission is given a running test on a dynamometer and a static test for oil tightness before it is passed to the despatch area.

Inspection

Rigorous inspection is necessary to ensure that the specified high standard of quality is maintained. Raw material control is carried out on conventional lines. For example, chemical analyses and metallurgical examinations are carried out on samples from every batch of gear blanks before the batch is released to production. Machining inspection is also carried out in a conventional manner by patrol inspection during operations and by final inspection of percentage samples before work is transferred to the finished parts stores. Statistical quality control methods are used to ensure that as far as possible remedial action is taken before, and not after, the work fails to meet specification.

In the production of individual components, percentage inspection is all that is necessary, but during the course of assembly 100 per cent inspection is carried out at certain points. For example, two valves are fitted into a central hole which is drilled for a length of about 14in in the mainshaft. These valves, incidentally, are frozen in liquid nitrogen to shrink them slightly so that they can be freely inserted into position. When they return to normal temperature and therefore towards their original dimensions they are locked fast in position. After these valves have been inserted, there is 100 per cent inspection to ensure that they function correctly.

Pinions for the epicyclic gear trains are also given 100 per cent inspection for noise level. Even slight imperfections in these gears can cause undue noise in operation. Because of this every pinion is run against a master gear on a Gear-Speed machine. There is also 100 per cent inspection on the front pump assembly and on the extension casing assembly which incorporates the rear pump. These are hydraulic tests carried out on special rigs, which include all the necessary instrumentation to ensure that the characteristics are correct for the application for which the transmission is to be used.

Every automatic transmission is individually tested on a dynamometer of the type shown in Fig. 16. In all there are five dynamometers, see Fig. 17, each capable of testing 80–90 units per day. On each dynamometer, the electric motor has its own electric speed indicator; the speed is regulated by a rheostat on the control panel. The conditions for the generator are pre-set, and a mechanical hand brake is available to simulate road conditions.

There are eight gauges on the dynamometer instrument panel. They record the pressures for the front pump, the rear pump, the converter, the multi-disc clutch, the forward servo, the low servo, the direct drive clutch and the reverse servo. The test procedure includes checks on safety devices

(the parking pawl and reverse interlocks) as well as checks on engagement speeds and the correct functioning of the freewheels. This equipment permits a most searching check on the functioning of the transmission to ensure that it operates in accordance with the specified gear-change pattern.

The unit, minus the oil pan and filter shroud, is lifted from the conveyor by electric hoist and is lowered on to locating pins on the dynamometer, where it is secured by hydraulically operated clamps. Movement of one hand lever engages the tailstock with the drive flange on the gearbox, and movement of another hand lever engages the torque converter in the dynamometer with the pump drive at the front of the box. (Incidentally, the converter in the dynamometer is an integral part of the test rig and is not the unit that will be used with the gearbox. Torque converters for use with gearboxes are tested separately.) Operation of a third lever, simultaneously and by hydraulic action attaches to the gauges all the pressure take-off points on the box, except for that for the rear pump which is attached by hand. If the box passes the tests, it is transferred to the final assembly conveyor where the filter shroud, oil pan and pressure take-off plugs are fitted. Finally, and outside the assembly department, the box is pressure tested for oil tightness.

Road tests are carried out daily on transmissions taken at random from those ready for despatch to customers. Each test is, of course, carried out in the type of car for which the transmission is to be used. Before the transmission is assembled into the vehicle, various points are checked, and after assembly into the vehicle, but prior to the road tests, other points are checked. The actual road test is divided into five divisions, each one dealing with one selector position. Although it is not possible in these notes to give the road test procedure, it may be said the tests is of a most comprehensive and searching nature to ensure that the transmission not only functions correctly but also has the correct characteristics for the application in which it is to be used.

Recent Publications

Brief Reviews of Current Technical Books

Reifen-Fibel (Tyre Handbook)

In German, by Hermann Schoepe.

Stuttgart: BERLINER UNION G.M.B.H., Germany. 1955. 7¼ × 5. 153 pp. Price D.M. 7.80.

This book has been written for the purpose of providing vehicle operators and service organizations with information on the engineering problems of tyre manufacture and use. Thus, by sponsoring better understanding, it should lead to greater safety and enable increased mileages to be obtained. The author has succeeded in presenting interesting and informative data in a clear and concise manner. Chapter 1 is headed Properties; it covers tyre sizes, adhesion, spring qualities, rolling resistance, etc. The remainder of the chapters are: Manufacture; Installation; Balancing; Wear; Defects; Maintenance; and Repair. An appendix deals with special tyre forms, as used for tractors and cross-country vehicles. This book should do a great deal to improve the understanding of tyre problems and should be welcome to car owners and designers who understand the German language.

Die Blendstörwirkung im Strassenverkehr (The Disturbing Effect of Glare in Road Traffic). Deutsche Kraftfahrtforschung, No. 90.

In German, by Helmut Lossagk, Dr. Ing.-Habil.

Düsseldorf: VDI-VERLAG G.M.B.H. 1955. 11¾ × 8¼. 20 pp.

Considering the importance of the subject of headlight glare, the amount of information available on its effect on accident rates is insignificant. This is surprising in view of the background of the ever-increasing density of road traffic. The necessity for devising objective methods of assessing the light conditions, in terms of the possibility of their being either the prime cause of or a contributory factor to accidents, becomes apparent when considering that the more usually adopted subjective methods of evaluation conceivably might lead to a miscarriage of justice.

Therefore, this monograph is an important and welcome addition to the literature on automobile and general road traffic safety. The ability to perceive an object encountered during night driving does not depend solely upon the light intensity in the horizontal plane, nor on the light projected from the vehicle headlamps. Data of this nature are in any case insufficient to determine the distance at which an obstacle can be seen by the driver. The obstacle is visible only if the intensity of the road or vehicle lights is such that the difference between the light reflected by the obstacle and that reflected by the surroundings, as seen by the driver, is greater than the brightness threshold of the area of the retina upon which the image is reproduced.

To investigate this aspect of eye reaction, a special glare interference meter was used by the author; this is dealt with briefly, together with a general discussion of its development. The various aspects of and data relating to light intensities are considered next. Then there are fourteen sets of graphs showing how the values of the brightness threshold are affected by different conditions encountered during night driving. These valuable data were obtained by the author and others by means of laboratory and road investigations. In this work, the information is correlated in such a form that it is of use to both the practicing engineer and the research worker. It concludes with a bibliography of one hundred references. The whole work is a most useful contribution to the literature on the subject, and it should be welcome not only to vehicle and accessory designers but also to police and legal authorities.

The Theory and Practice of Lubrication for Engineers.

By Dudley D. Fuller.

New York: JOHN WILEY AND SONS, INC.

London: CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1956. 9 × 5¾. 431 pp. Price 84s.

This is said to be the first book to offer a complete treatment in English of hydrodynamic theory, with emphasis on the engineer's point of view. The author has aimed, with great success, at presenting the theory of lubrication to the engineer in the most understandable and usable form. To begin with, the theory of lubrication is dealt with in a most lucid manner, and the principles enunciated are then applied to a wide range of lubrication problems. In the discussion of the problems, numerous examples are worked out. In addition, many bearing designs are also given.

The work is divided into 12 chapters of which the first, as is only logical, deals in 22 pages with the fundamentals of viscosity and flow. In the second chapter, which runs to 55 pages, viscosity and its variables are dealt with in some detail. Hydrostatic lubrication is considered in the third chapter, 44 pages, and hydrostatic squeeze films in the fifth, 20 pages. Hydrodynamic lubrication, which is perhaps the most important for the automobile engineer, is then dealt with in two chapters. The first of these occupies 46 pages and deals with general principles, while the second, 31 pages, is concerned solely with hydrodynamic lubrication of journal bearings, certainly the most widely used and probably the most useful bearings. A valuable section of this chapter is devoted to practical design considerations.

Friction and power losses in journal bearings are considered in the seventh chapter. The study of this chapter and the application of the knowledge gained is strongly recommended as a means of avoiding bearing failures. Some typical industrial bearings form the subject of the eighth chapter and air-lubricated bearings that of the ninth. Dry friction and boundary friction are the subjects of the next two chapters.

The final chapter deals with bearing materials. Most of this chapter is, of course, concerned with the commoner bearing materials, but the properties of the lesser used materials are also discussed. A bibliography is appended to each chapter and the work is adequately indexed.

ALUMINIUM FOR RADIATORS

A Résumé of American Investigations and Developments

DURING the past few years, much work has been done to develop aluminium automobile radiators. Interest in the subject has recently been increased by the higher cost and relative shortage of competitive materials. Aluminium radiators are also attractive because of their light weight and good heat transfer properties. Some of the experimental work carried out on this type of radiator was recently described to the Society of Automotive Engineers in New Jersey by J. D. Dowd and D. G. Vandenburg, both of Alcoa Research Laboratories, and E. P. White of the Aluminium Company of America.

The various types of construction and materials that have been considered for aluminium radiators are summarised in Table I. Some of the combinations shown have reached the commercial development stage, whereas others have been made and tested only on a laboratory scale. All full-scale and most small-scale work has been conducted with tube and fin radiators having either corrugated or flat fins. Experiments have been made with cellular radiators, but the results were not entirely satisfactory.

Aluminium can be incorporated into tube and fin radiators in two ways. It can be used for fins only, with the tubes, tanks and fittings made of brass; or it can be used for the entire radiator. It is agreed by many that all-aluminium radiators made by either soldering or brazing will ultimately be adopted. Industry at present favours the aluminium-brass construction, however, because it entails only minor changes in existing manufacturing facilities and procedures. Corrosion problems of the water side of this type of radiator are also expected to be the same as for present types. Furthermore, leaks could be repaired by most of the techniques employed in repairing brass-copper cores.

Aluminium-brass radiators

Aluminium-fin, brass-tube radiators are fabricated by the same techniques used for copper-fin, brass-tube radiators. To obtain an assembly having adequate resistance to corrosion, however, it is necessary that solders specifically designed for aluminium be used. Table II lists some preferred solders and their performances and costs. Joint and corrosion tests on assemblies made with a wide variety of solder composition, indicate that zinc-tin and zinc-cadmium solders having more than 70 per cent. zinc are the most satisfactory for aluminium-brass radiator cores. Trace-element additions have also been made to the compositions to improve soldering characteristics. The lead-tin solders now used for copper-brass cores are unsatisfactory for aluminium-brass cores because of corrosion problems.

Several types of flux are available for use in soldering aluminium fin-brass tube cores. Some of these are organic solutions that are non-corrosive; others are inorganic salt mixtures and are corrosive. Residues of the salt fluxes must be removed subsequent to soldering to prevent increased corrosion of the soldered joints.

The procedures for furnace soldering aluminium-brass radiator cores are essentially the same as those now employed for furnace soldering copper-brass cores. With the aluminium fin construction, however, the times and temperatures for coating the brass tubes and for soldering the cores must be controlled more closely to prevent excessive penetration and diffusion of the solder into the brass tubes. When the conditions are properly adjusted, consistently good furnace soldered aluminium-brass cores can be obtained.

All-aluminium radiators

By far the most experience in fabricating all-aluminium radiators has been with brazed assemblies. In such assemblies, brazing sheet is used for the tubes, headers, and tanks, with bare or Alclad aluminium for the fins. Alloys used in brazing aluminium are relatively high in silicon content. The brazing material most frequently used for radiator construction is known as 4343 alloy, and has a metling range of 1,070 to 1,135 deg F. Basic sheet material for radiators is 3003 alloy, with a melting range of 1,190 to 1,210 deg F.

In making brazed radiators, the tube and fin components are first assembled into cores. These cores are degreased, preheated, to about 1,000 deg F., and dip brazed into a molten salt flux bath at about 1,120 deg F., after which they

TABLE I. AUTOMOBILE RADIATORS

Types and Components			
Tubes	**Fins**	**Joining Material**	**Joining Process**
I. Aluminium-fin brass-tube radiator			
A. Fin and tube type			
Brass tubes Solder coated	Alclad 3003 or 3003	90 Zn—10 Cd 70 Zn—30 Sn	Furnace soldering
Brass tubes Solder coated	Copper coated 3003	70Pb—30 Sn	Furnace soldering
B. Cellular type			
Copper or brass tubes Solder coated	Copper coated 3003	70Pb—30 Sn	Dip in solder
II. All-aluminium radiator			
A. Fin and tube type			
No. 100 Brazing Sheet No. 11 Brazing Sheet	Alclad 3003 or 3003	Brazing alloy 4343	Dip brazing Furnace brazing
B. Cellular type			
Alclad 3003 3003	Alclad 3003 or 3003	Zinc 95 Zn—5 Al	Dip in solder

TABLE II. CHARACTERISTICS OF SOLDERED BRASS-TUBE, ALUMINIUM FIN ASSEMBLIES

	Zn[1]	95 per cent Zn 5 per cent Al **Solder**	90 per cent Zn 10 per cent Cd **Solder**	70 per cent Zn 30 per cent Sn **Solder**	70 per cent Pb 30 per cent Sn **Solder**
Density, lb/in³	0.258	0.239	0.262	0.260	0.351
Liquidus temperature	790 deg F.	720 deg F.	750 deg F.	710 deg F.	500 deg F.
Coating evaluation	Fair	Fair	Good	Good	Excellent
Contamination of solder by brass	Moderate	Moderate	Slight	Slight	Little
Strength of soldered joints	Strong	Strong	Strong	Strong	Weak
Relative corrosion evaluation[2]					
Brass—Al cores	A	A	C	C	D
Brass—Cu cores	A	A	B	B	A
Cost factor, per cent of 70Pb—30Sn[3]	29	27	58	72	100

[1] *This solder combination is commonly used for copper-brass radiator construction and is shown in this table for comparative purposes only.*

[2] *A is highest rating.*

[3] *For equivalent coating thickness.*

are cleaned to remove any residual flux. This procedure gives satisfactory radiator cores, but is expensive because of the major changes required in plant and procedure and the difficulty in removing all the residual flux. Furnace brazing would be more desirable because it is similar to furnace soldering which is now used ; the residual flux could also be removed more readily. The development of adequate furnace brazing procedures is being actively pursued.

Although brazing has been used most extensively in making all-aluminium radiator cores, it is believed that satisfactory furnace soldering procedures can eventually be developed. From a fabricating viewpoint, this would be decidedly superior to brazing because lower temperatures can be used and the control of joining times and temperatures will not be so critical. Furthermore, the repair of leaks might be more easily accomplished.

General corrosion considerations

An important consideration in selecting aluminium alloys for automobile radiators, is their relative resistance to corrosion. An application that closely parallels the use of aluminium fins on radiators is the use of aluminium fins for the evaporator and condenser coils of air conditioners. For such units, aluminium fins mechanically bonded to copper tubing have become standard. Aluminium heat exchanger tubes have demonstrated their ability to handle many types of water.

There are several basic factors that should be kept in mind when considering corrosion resistance in aluminium radiators. Perhaps the most important of these is that aluminium is protected to a large extent by the thin oxide film that forms spontaneously on an aluminium surface exposed to the atmosphere. This oxide re-forms when it is scratched or otherwise damaged. Another valuable characteristic of aluminium alloys is that the rate of corrosion decreases with the period of exposure in many environments. This characteristic has been shown by comprehensive tests of various aluminium alloys exposed to different atmospheres for up to 20 years, as well as by examination of samples taken from actual installations.

Another factor to be considered is the solution potential relationship of the alloys encountered in radiator construction. The solution potential of a metal is dependent upon the composition and temperature of the solution. Laboratory measurements indicate that in most radiator coolants, the metals are arranged by solution potentials in the order shown in Table III. These relationships become an important consideration when assessing corrosion because, when dissimilar metals are in contact and exposed to an electrolyte, galvanic cells result. The hazard of accelerated localized corrosion, resulting from galvanic action, exists at the interface between the aluminium fin and the solder fillet in the aluminium-brass radiator. In contrast, galvanic relationr ships are used to advantage in Alclad aluminium radiatotubes.

Alclad aluminium products were developed to resist the highly localized attack sometimes encountered on non-clad aluminium products. As the name suggests, an Alclad product is a composite consisting of an aluminium alloy core having a metallurgically bonded cladding of another aluminium alloy on one or both surfaces. The alloys for the cladding and core are selected so that the cladding will be anodic to the core. The electrochemical protection furnished by the cladding prevents attack of any exposed core alloy.

Corrosion test procedures

The corrosion resistance of aluminium for radiators and similar equipment has been investigated for more than 15 years. A comprehensive programme to evaluate the performance of both the all-aluminium-brass radiators has been under way since 1946. The solution potentials of the alloys considered for radiator service were studied in many coolants, both at room and higher temperatures. These data have been helpful in interpreting results of corrosion tests and in selecting materials. Most of the work has been on assemblies designed to simulate actual radiator construction. The emphasis was placed on evaluating the performance of the thin wall tubes and on the tube and fin joints,

TABLE III. GENERAL ORDERING[1] OF METALS AND ALLOYS BY THEIR SOLUTION POTENTIALS IN MOST FRESH WATERS[2]

Magnesium
Zinc
Aluminium alloy—7072
Aluminium alloys—1100, 3003, 6061, 4343 Cadium
Aluminium alloy—2024-T6
Steel
Lead Tin
Brass (70-30 or 85-15) Copper Stainless steel—Type 304

[1] *A material is anodic to those materials below it in the series and cathodic to those above it. The potential differences among the materials within a group, however, are of small magnitude.*

[2] *Solution potentials dependent on composition of water and temperature. Ordering will change in some solutions.*

which were considered to be the components most susceptible to corrosion.

To assess the resistance to corrosion of radiator assemblies, it is essential to make the tests as practical as possible. Static tests to simulate interior exposure were conducted in various waters with and without different inhibitors and anti-freezes. To simulate exterior environments experiments were made by continuous and alternate immersion in waters, and by exposure to salt and brine spray, humid conditions and atmospheric test stations.

In addition to the static tests, simulated service tests were employed in which coolants were periodically heated and pumped through the tube specimens. Exterior corrosion was evaluated in similar tests by spraying at scheduled intervals the outside surfaces of the specimens with various solutions and suspensions which might be encountered under adverse service conditions. The duration of these tests was varied from a few weeks to more than three years. Brazed aluminium radiator tubes, for example, satisfactorily resisted corrosion in coolants normally encountered in radiators. Extremely severe environments had to be employed in order to test the various combinations in a reasonable length of time.

The selection of test environments for testing exterior corrosion was made difficult by the absence of adequate service data. Although the exterior surfaces of radiators might appear exposed to severe conditions, laboratory tests and recent service performance have shown that exposure is relatively mild. Radiators are fairly well shielded from splashes by grilles. Moisture is quickly evaporated by heat or air during operation or by the residual heat after cars are stopped.

Test results on aluminiun-fin brass-tube radiators

The corrosion tests of the coolant side of the aluminium-brass radiator was confined to evaluating the various solders in the brass tube seams because any corrosion by the coolants must occur in the soldered tube seam or the brass itself. The zinc-cadmium and zinc-tin solders have given encouraging performance in the brass tube seams in laboratory tests. Solders containing large amounts of zinc are, however, more anodic to the brass than the lead-tin solders now used, and therefore in severe coolants may be more subject to selective attack.

With aluminium-brass radiators, the critical factor is the resistance to corrosion of the soldered joints between the aluminium fins and the solder-coated brass tubes. Loosening of these joints in service would result in loss of cooling capacity. In laboratory tests, such joints made with various solders were found to fail rapidly in severe environments. Some of the failures were caused by corrosion of the anodic interface formed between the solder fillet and the aluminium fin. Other failures occurred through the body of the solder fillet.

The relative corrosion ratings, based on laboratory test results, are shown in Table II for the more promising solders. Although not considered practicable at present for production joining, pure zinc and zinc-aluminium solders were found to provide outstanding resistance to corrosion. In laboratory tests, aluminium-fin, brass tube specimens joined with these solders performed as satisfactorily as samples from standard copper-brass radiators made with lead-tin solders. Of the solders that are practical for joining aluminium to brass, the zinc-cadium and zinc-tin solders were equally good and markedly superior to lead-tin.

In accelerated tests, wide variations were observed in the performance of joints made between aluminium and brass with a given solder. These variations are believed to be dependent upon factors such as the thickness of the solder, coating on the brass tube, joining time and temperature, flux composition and how completely it is removed. Similar variations have been observed in copper-brass radiators. These findings emphasize the necessity of careful control in manufacture, to produce high-quality radiators.

In view of the hazard of external corrosion in the soldered joints, protective measures are advisable to improve the performance of aluminium-brass radiators. A recommended measure is to cover the exterior surfaces with a suitable paint which may be used in conjunction with a chemical treatment. To obtain the standard black finish desired by the manufacturers, either the protective paint may be pigmented with carbon black or a top coat of black paint may be applied over the protective paint. The resistance to corrosion of these assemblies may be further enhanced by the use of Alclad fins.

Test results on all-aluminium radiators

In all-aluminium radiators, the performance of the aluminium tubes in contact with the coolants must be assessed. To obtain maximum resistance to corrosion by a variety of coolants, the Alclad product was considered advisable. Accordingly, Alcoa No. 100 Brazing Sheet (formerly known as No. XA30 Brazing Sheet) was developed and recommended for use in tubes and headers. This product is a composite sheet having a 3003 alloy core with an aluminium-silicon brazing alloy on one surface and a cladding of an aluminium-zinc alloy on the other surface. The aluminium-zinc cladding is anodic to the 3003 core and is placed on the water side to obtain electrochemical protection.

As a result of many and varied laboratory tests, a definite advantage for the Alclad coating on brazed aluminium radiator tubes has been demonstrated. In limited radiator service tests, however, satisfactory performance has been reported from both No. 100 Brazing Sheet and No. 11 Brazing Sheet construction. No. 11 Brazing Sheet is similar to No. 100 Brazing Sheet except that it does not have the aluminium-zinc cladding. From these tests, aluminium radiator tubes would be expected to have a high resistance to a wide variety of coolants.

To avoid galvanic corrosion on the coolant side, the best radiator design should employ aluminium for all components including items such as drain valves. If other materials are selected for certain parts, however, compositions compatible with aluminium should be specified.

The aluminium-silicon alloy joints between the fins and tubes in the brazed all-aluminium radiator have a high resistance to corrosion in a wide variety of environments. For this reason, the brazed aluminium radiator will not lose cooling capacity because of loss of contact between fins and tubes. For the most part, the exterior brazed surfaces of the tubes in the all-aluminium radiator have offered satisfactory resistance to corrosion. In a few scattered cases, however, small perforations have occurred in the tube walls as a result of localized corrosion starting on the exterior brazed surfaces. In this design, the brazing alloy on the outside of the tubes has about the same solution potential as the 3003 core and will not provide electrochemical protection to the core. The outside surface, therefore, does not have as high a resistance to perforation as the interior Alclad surfaces.

Several methods have been developed and are recommended to minimize the susceptibility of outside brazed surfaces to localized attack. These preventive measures include electrochemical protection by anodic fins and by selected organic coatings. Anodic fins, such as alclad sheet, have been found in laboratory tests to provide substantial protection to the exposed areas of the exterior brazed surfaces of the tubes. In conjunction with, or as an alternative to, fins of an anodic alloy, the exterior surfaces of the radiator may be covered with a protective paint that may be combined with a chemical treatment.

Faster Profile Grinding of Spur Gears

The Orcutt Gear Grinding Machine with Fully Automatic Operating Cycle

To meet the exacting requirements of the modern automobile industry, increasing use is made of ground gears of a high order of accuracy on tooth profile and concentricity, and having a good surface finish. By the nature of the industry these features must be coupled with a high rate of production and it was specifically to satisfy such demands that The Gear Grinding Co. Ltd., Shirley, Birmingham, designed and developed this fully automatic machine. It is capable of grinding gears to the highest standards of precision, as are required for components of aircraft power units, while at the same time reducing the floor-to-floor time on the work.

The machine, Fig. 1, resembles the well-established Orcutt H.M. gear grinder in general appearance, but it removes the grinding operation entirely out of human cohtrol; the operator being required merely to unload and load the work and to start the machine by push-button. A complete grinding cycle is programmed on a special control unit incorporating the feed cams. Feeds are applied once every revolution of the work and the grinding wheel is withdrawn, redressed, and returned to the operative position at any desired stage or stages in the cycle. Grinding, reciprocation, indexing, feed, and wheel dressing are all controlled electrically. A hydraulic cylinder is employed to effect the actual feed movement.

By the use of an automatic cycle the depth and the number of feeds and the number of wheel dressings are determined in advance and freed from human vagaries. Production rates are increased, since optimum grinding rates can be established and thereafter maintained. This is of particular importance when gears of highly alloyed steels are being ground and strict control of operating conditions must be maintained in order to avoid surface tempering of the work. Once the conditions have been determined they are programmed into the machine and are consistently repeated.

The control mechanism is designed to permit easy and rapid adjustment and, in conjunction with the new type of wheel trimmer by which exact profile is determined by means of hardened and ground form plates, machine setting times are substantially reduced from those previously required. It is this factor that renders the automatic machine suitable for general use on small batch quantities as well as for long runs. It can, indeed, be used with advantage on batches as small as ten components. With it a higher standard of accuracy is obtained, together with consistency in production. Fig. 4 shows automatic machines, replacing normal control models, engaged on general work in the builder's machine shops.

Overall, the space occupied by the machine is 8 ft × 3 ft 9in × 6 ft high and the net weight is approximately 3 ton 8 cwt.

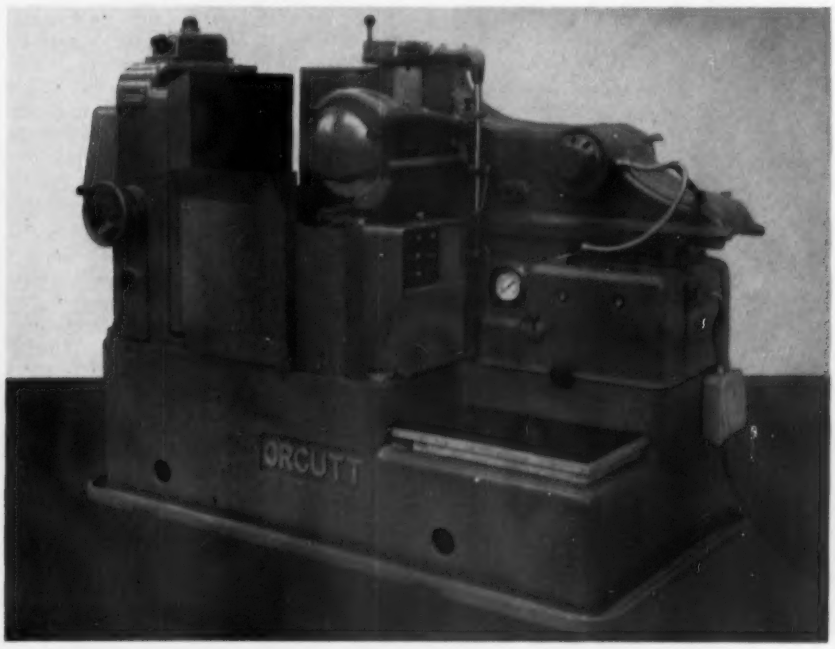
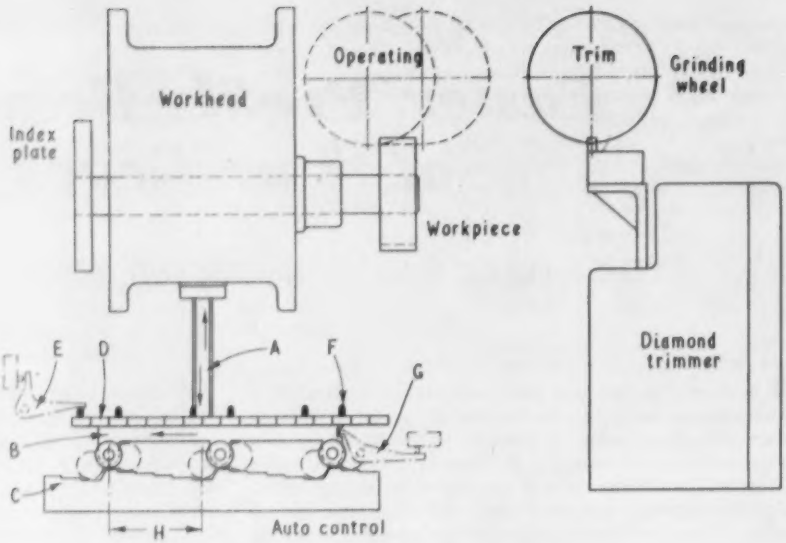


Fig. 1. The Orcutt automatic gear grinding machine



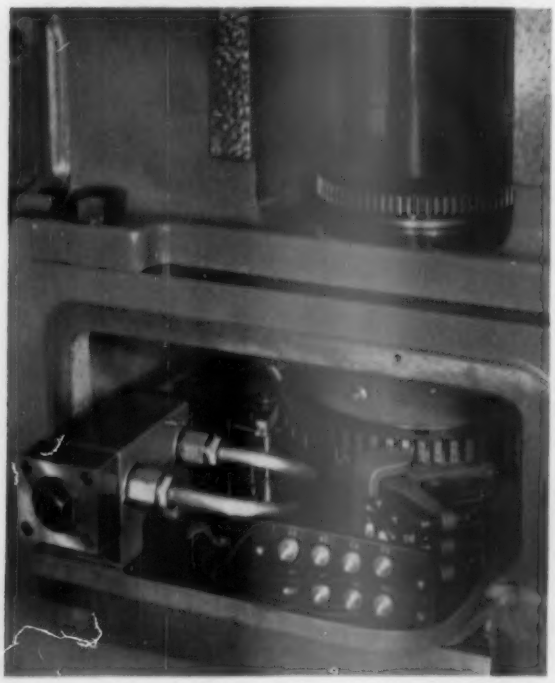
A—workhead elevating screw, B—control disc, C—feed cam, D—ratchet plate, E—trim position limit switch, F—trim position actuation peg, G—depth control limit switch, H—travel during one grinding cycle. Number of feeds from 6 to 20

Fig. 3. Diagram of automatic cycle and feed control

It can handle gears of from 2in to 24in outside diameter and of face width up to a maximum of 8in, dependent on the size of the gear. Tooth pitches may be from 16 D.P. to 2 D.P., or 1·5 Mod. to 12 Mod., and the number of teeth from 10 to 150. A detachable centre attachment is provided which enables stem gears, or a gang of gears mounted on an arbor, to be ground between centres. The capacity of this attachment is up to 10in diameter and 10in between centres.

Merely as an indication of the production times to be expected, the example may be quoted of two gears having 20 teeth of 8 D.P. and 20 deg pressure angle, ganged together and ground simultaneously. The total face width was 2·25in and the stock allowance in this instance was 0·006–0·007in on each flank. The floor-to-floor time was 12 minutes, or 6 minutes per gear. To profile grind at such rates a reasonable standard of gear preparation is necessary. Cams are designed to provide a succession of feeds to an overall depth of feed which, for obvious reasons, should be held to a minimum. Suitable conditions can be obtained by cutting the teeth of the gear to a consistent chordal thickness to a limit of 0·002in and using suitable cutters that dispose the grinding stock to the best advantage. Further, it is recommended that the root should be relieved during cutting wherever possible so that subsequent grinding becomes unnecessary. This practice enables feeds to be increased, the total feed depth to be reduced, and the cycle time materially shortened.

Fig. 2. The cycle and feed control unit can be withdrawn from its housing for re-setting



To permit relatively coarse feeds and at the same time to obtain good surface finish on the work, particular care has been taken to provide a rigid and vibration-free grinding wheel spindle running in plain bearings. These bearings are steel-shell, white-metalled bushes formed on the external periphery with five longitudinal splines. They are pressed into a housing with an interference fit and consequently the bore has five bearing lands which cause the spindle to run on a wedge-section oil film. Tolerances between the spindle and the bearings are so close that only a specified low-viscosity lubricant must be used. As a further precautionary measure against the possibility of transmitted vibration, the 4 h.p. main spindle motor and the 2 h.p. hydraulic pump motor are each fitted with plain bearings Both run at a speed of 1,440 r.p.m.

Automatic cycle and feed control

The mechanism for controlling the feed of the workhead to the grinding wheel, the dressing of the grinding wheel at predetermined intervals, and the stopping of the machine at the conclusion of the cycle, is assembled on a tray housed in the foot of the workhead column. To facilitate setting it can be withdrawn as a unit and supported outside the housing on a pair of substantial hinged struts. In Fig. 2 the control unit is shown exposed preparatory to withdrawal. The struts are folded in their inoperative position alongside the housing. A schematic arrangement of the control mechanism is given in Fig. 3.

Under working conditions the weight of the workhead is taken through the elevating screw to A to the control disc B

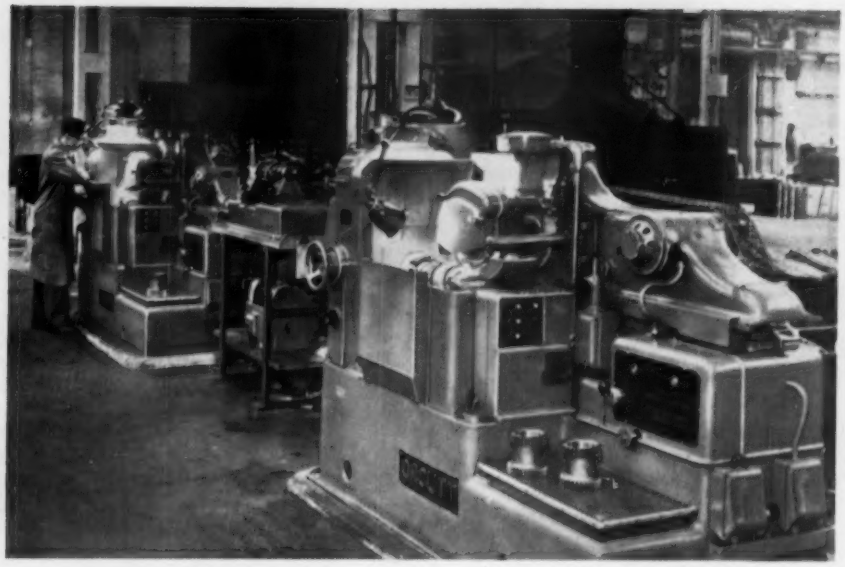


Fig. 4. Automatic machines used for short and medium runs of general work in the Company's shops

which, in turn, is supported by three evenly spaced rollers resting on the feed cam C. This cam is a disc of hardened steel having on its upper face a shallow upstanding rim into which are ground three series of steps, see Fig. 5. In operation the rollers climb the steps on the cam and feed the work to the grinding wheel. Each 120 deg of the cam is formed with an identical number of steps appropriate to the number of feeds required to complete a particular gear, and one revolution of the control disc over the feed cam controls the grinding of three consecutive loadings of gears. Feed is applied when a pawl on the index plate operates a switch after the work has made a complete revolution. This switch controls the plunger of a hydraulic cylinder. Movement of the plunger actuates a pawl, which engages a ratchet plate D, and indexes the control disc from one step on the feed cam to the next.

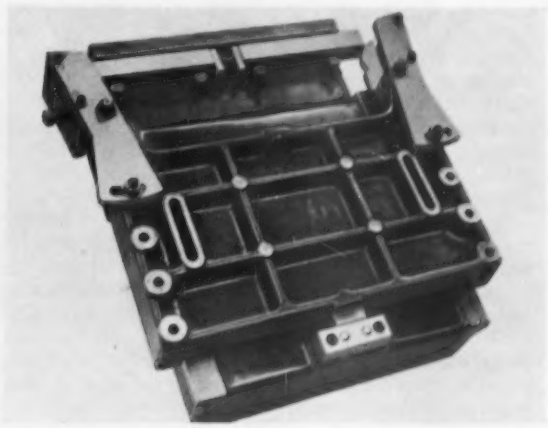
To enable the requisite angular movement to be obtained to suit different feed cams, ratchet plates having different numbers of teeth are required. Five plates having 36, 42, 48, 54, and 60 teeth are supplied with the machine as standard equipment and with these it is possible to provide 6, 7, 8, 9, 10, 12, 14, 16, 18, or 20 feeds to complete a gear. Limit switches actuated from the ratchet plate and the control disc control the operating cycle. Switch E causes the grinding head to move to the trim position when its bell-crank lever is tripped by a taper peg F fitted to the ratchet plate. The pegs may be positioned to give a re-trim at each revolution of the gear, down to merely twice a cycle, as desired. From the control disc, switch G controls the depth position and operates a green warning light. A similar switch stops the machine at the conclusion of the cycle and operates a red light to indicate that the machine is ready for unloading. These three switches will be seen grouped one above another on the right of the control unit, Figs. 2 and 5, while the hydraulic cylinder is on the left.

Resetting cycle and feed control

When it is desired to change the feed cam and reset the cycle, the workhead is raised by means of a hand wheel and the weight is taken by a retractable abutment. Further

Fig. 5. The stepped feed cam is here shown exposed after removal of control ring and ratchet plate

Fig. 7. Trimmer form plate mount on special setting fixture. Precise setting is obtained by means of slip gauges



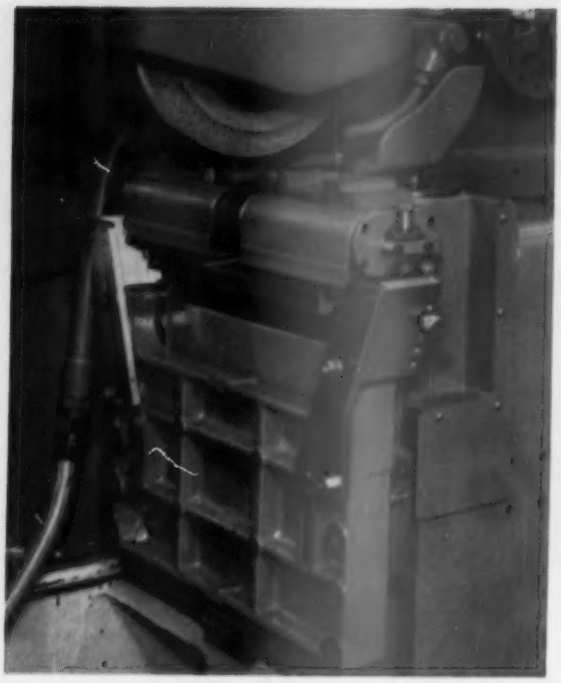


Fig. 6. The new automatic wheel-trimming device

winding of the hand wheel lifts the nut on the elevating screw from the centre of the control disc. Immediately the nut is clear of the upper face of the disc, the complete control unit on its tray can be drawn out and supported on the hinged struts. After withdrawing the pawl pin from the control disc, the control disc assembly can be lifted off to give access to the feed cam. Both the feed cam and the ratchet plate can then easily be changed. The time taken for the complete operation need not exceed 15 minutes.

It may be noted that it is often unnecessary to remove the feed cam and replace an alternative one when changing over from one batch of work to another as a particular cam can be used for grinding quite a wide range of gears. In this connection the feed to depth and the preparation of the gear are the factors of major importance.

Automatic wheel trimmer

The technique adopted with this new wheel trimming device, Fig. 6, is entirely different to that employed with the earlier model and constitutes a notable advance in design. Previously, a pantograph type trimmer used one pair, from a range of four or five pairs, of soft form plates for the grinding of a particular gear. This enabled adjustments to the shape of the involute curve to be made to meet specific requirements. There was a concommitant disadvantage, however, since it was not possible to pre-determine fully the setting required and consequently setting time was relatively protracted.

With the new equipment only a single pair of hardened and ground form plates is required and they are set up with slip gauges to precisely predetermined positions on their mount on a special form-setting fixture. Form plates are each located from a large diameter bore, and from this bore the form is generated from a base circle of the dimensions of the gear to be ground. It should be noted that this trimmer can only repeat the shape that is given by the form place and, therefore, it is necessary for any modification to shape to be determined in advance and embodied in the form plates. Through this advantage of shape control, preparation is substantially reduced to a closely predictable figure.

Symmetrical chisel-shaped Diatorc trimmer diamonds are mounted in a pair of slides which are spring-loaded for horizontal movement against the form plates. The complete trimmer front carrying the form plates is raised and lowered so that the followers on the outer ends of the slides traverse the form plates and impart an equivalent movement to the slides and thus shape the grinding wheel.

Setting the wheel trimmer

To set the trimmer, the ribbed form plate mount is detached and positioned on the slideways of a special fixture, Fig. 7, being located by a slip gauge against a fixed abutment. After the locking screws for the form plates are released, slip gauges are inserted between a central abutment and the inner ends of two setting bars by which the spacing of the form plates is established. The dimensions of the slip gauges to be used are determined in advance from formulae. The form plates, located on the bores already mentioned, are adjusted until their profiles contact the corners of the outer ends of the setting bars and are then locked in position. This completes the setting operation, and it remains merely to unload the mount from the fixture and to return it to the trimmer assembly.

The trimmer is immediately ready for use to give correct shape to the grinding wheel, and gears can be ground to finished size. Only minor adjustments may be required for depth and thickness. Adjustment for thickness is made by means of micrometer screws, one of which may be seen in Fig. 6. Thereafter, the wheel will be trimmed to the required shape until the wear on the diamonds becomes excessive. At that stage the worn diamonds are removed and either new or re-lapped diamonds mounted in their place. By using the setting gauge provided, it is unnecessary to remove the form plate mount or to alter the setting of the form plates.

The accuracy of the trimmer copying mechanism and form plates is of an order that enables specified modifications to involute profile to be produced consistently to limits of 0·0002in. To ensure a surface finish of high standard while

Fig. 8. Wheel hood removed to show root trimmer

maintaining a high rate of production, a two-speed trimming control has been developed. The trimming speed is set to give a rough trim for initial feeds and is changed automatically to a slow-speed fine trim for the final cut.

Root trimmer

The fillet radii on the grinding wheel are trimmed by means of a pair of Diatorc diamonds carried on the end of the diamond lever, as shown in Fig. 8. This lever is mounted on a spindle arranged for both pivotal and axial movement. The diamonds are moved horizontally to bring them successively into contact with the flanks of the wheel and are raised and lowered by pivoting in response to a radiused form plate moving across two fixed follower plates. A reproduction ratio of 1 : 1 is obtained as the lever carrying the form plate is of equal length to the diamond lever.

In Fig. 9 is shown the setting device for this trimmer. The form plate of hardened and ground cast steel is mounted in a slideway on the end of the lever and is adjustable for height by a micrometer screw. The relationship of the two fillet radii on the wheel is governed by the position of the two follower plates. Each follower plate can be moved horizontally by swinging about a pivot pin and can be raised or lowered by movement of the pivot pin. Initial setting of the device is made by moving the complete trimmer bracket in its vertical slideway. Micrometer screws are provided to facilitate all these adjustments.

Auxiliary equipment

When a number of similar gears are ganged on an arbor for simultaneous grinding it is essential that they are accurately aligned. To facilitate this setting a simple fixture is available, comprising a pair of centres slidably mounted on a base. This base also has a cross slide which carries a setting gear, of appropriate pitch and of adequate width, to engage the gears freely mounted on an arbor between the centres. By means of a cam mechanism on the cross slide the setting gear is mated and brought into hard contact with the ganged gears, forcing them into alignment. While so held, the lock of the arbor is tightened to secure the gears.

Fig. 9. Setting adjustment for automatic root trimmer

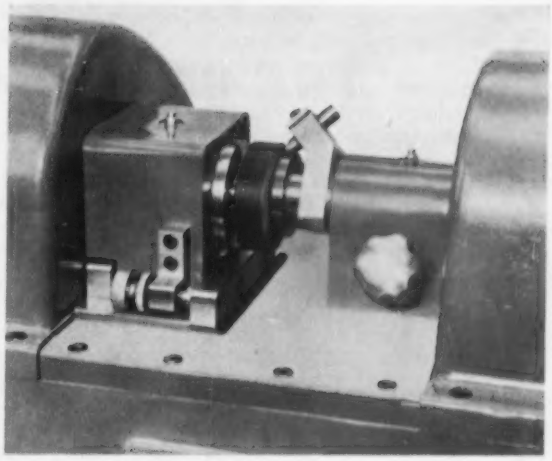
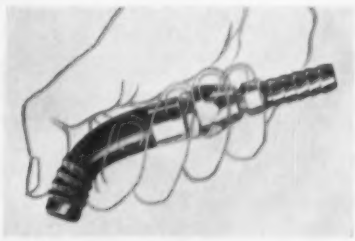


Fig. 10. Lapping machine for the trimmer diamonds used on the automatic grinding machine

To enable users to lap their worn wheel-trimming diamonds, a small bench type diamond lapping machine, Fig. 10, has been designed. It consists of two operating heads mounted on a box base which houses the ¼ h.p. motor for driving the two spindles. The spindle on the left rotates a diamond lap at high speed while that on the right rotates the trimmer diamond at a relatively low speed. Projecting beyond the suitably inclined diamond carrier is a hardened setting disc. The diamond, lightly held in the carrier, is adjusted axially until one of the two facets is supported on the periphery of the disc and the second facet is thereby positioned for lapping.

While the spindles are parallel, they are offset in one plane and thus the diamond follows an eccentric path across the face of the rotating lap. The lapping head is mounted on a slide for a limited axial movement and a loading device maintains the lap at a constant pressure against the diamond during operation. A micrometer stop controls the extent of movement permitted. When one facet has been reformed, the diamond is reset by turning 180 deg in the carrier and the operation is repeated on the other facet.

The Drumag Blow Gun



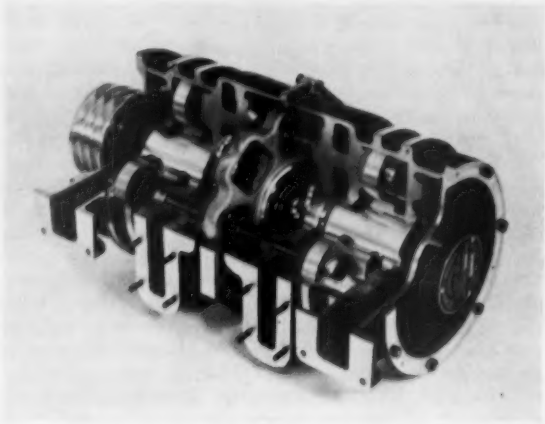
A resilient rubber nozzle is the outstanding feature of this new blow gun. At rest the nozzle is straight and the valve automatically remains closed. It is operated, as shown, merely by bending the nozzle and directing the stream of air as required. There is no external valve, button or lever susceptible to damage in use. Manufactured in Switzerland, it is distributed by E.F. Allchin and Co., 137, High Street, Aston, Birmingham.

THE WELLWORTHY-RICARDO SUPERCHARGER

A High-Efficiency, Compact and Reasonably Lightweight Unit

IN commercial and public service vehicle development, great stress is now laid on designing for light overall weight. This means, of course, that a specific power : weight ratio can be maintained with a smaller capacity power unit. It does not, however, necessarily follow that with normal aspiration the adoption of a smaller engine will lead to optimum fuel consumption. In fact, a comparatively large engine that works in the middle speed range—where efficiency is greatest—may be a more economical service proposition for fuel economy, reliability and long life. A high-torque engine can operate in conjunction with a high overall ratio transmission yet, in lightweight vehicles, retain good acceleration. A small engine, of from five to six litres capacity, is at a disadvatage compared with a seven to eight litre engine, since to obtain satisfactory performance a low overall gear ratio is necessary. This of course, means that the engine is operating largely at the top end of the speed range—which extends some 400 r.p.m. further than in larger engines—where performance is not economical. Moreover, specific fuel consumptions tend to increase as engine size is decreased so that a 5½ litre engine will give consumption in the order of 0·39 lb/b.h.p.-hr against 0·36 lb/b.h.p.-hr for an 8 litre unit.

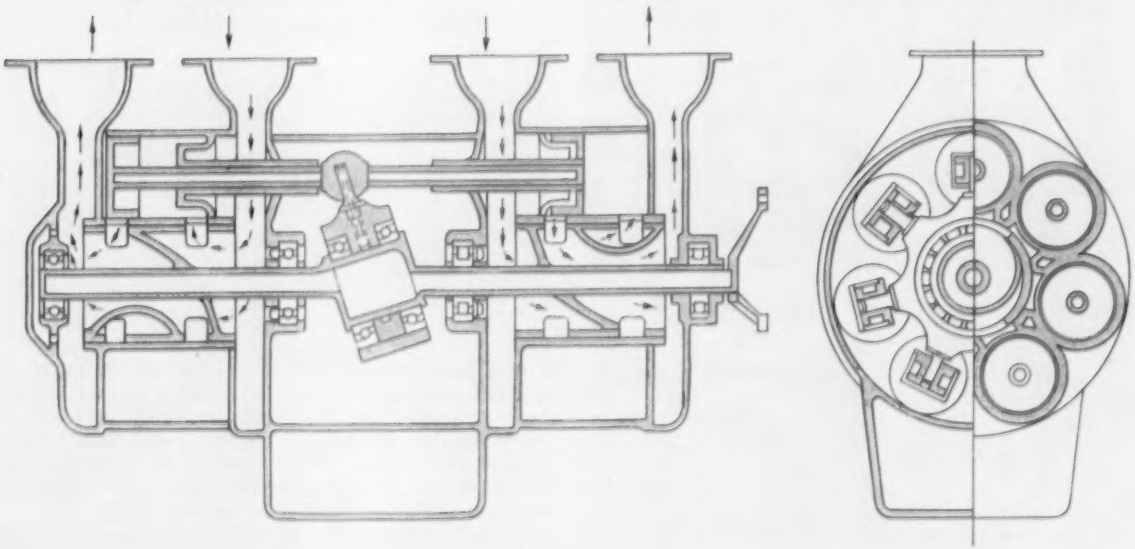
The employment of large engines is, however, contrary to the current trend of lightweight design. They are heavy and they are bulky ; in turn, this calls for more rugged engine mountings and a stronger frame, especially for underfloor mounting, where the engine forms a concentrated load within the wheelbase. Recent trends are, therefore, to develop as much power as possible from the small diesel engine. Two methods are popular ; one is to increase the swept volume of the engine by boring out the cylinders to a larger diameter and perhaps lengthening the stroke, and the other is to supercharge.



Sectioned view of the Wellworthy-Ricardo supercharger

Boring-out is cheap but has a practical limit set by the water jacket thickness; so much so, in fact, that some manufacturers have converted engines from dry cylinder liners to wet in order to obtain as thin a cylinder jacket as practicable and improve heat transfer. In any case, boring-out will seldom increase an engine's capacity by more than 50in³, which is about 15 per cent. By supercharging, however, power output can be stepped up by from 40 to 50 per cent,

This diagrammatic sketch shows the wobble-plate and Z-crank method of piston actuation and the air flow through the rotary valve



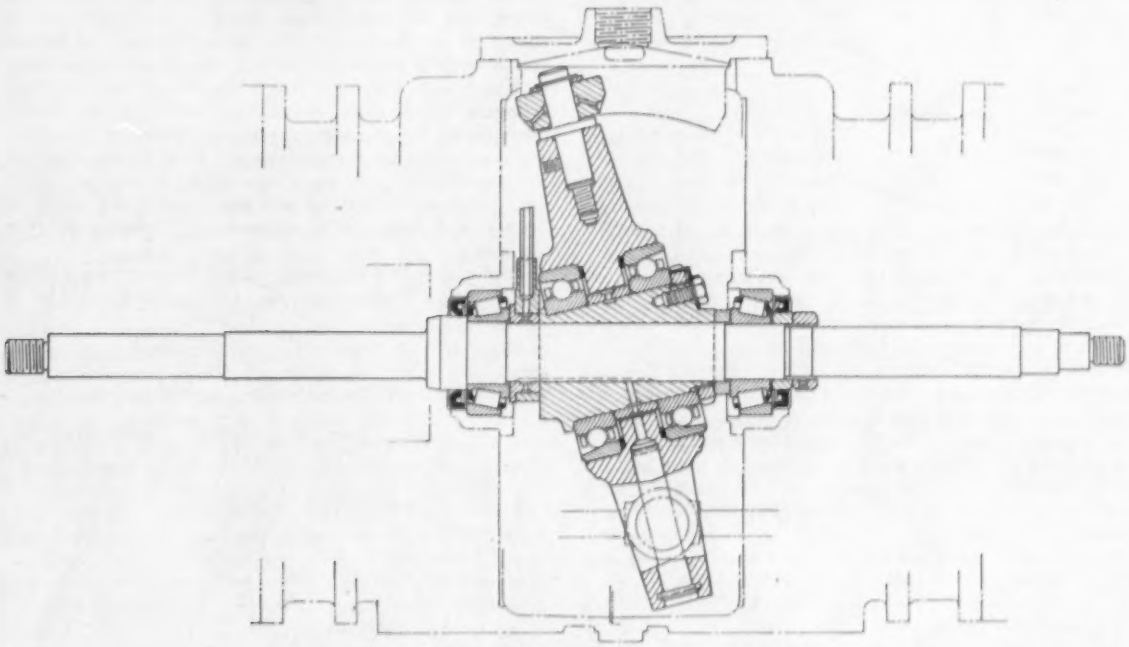
so that a small engine is endowed with the characteristics of a larger one, for the addition of only 80 lb weight, in the case of a Wellworthy-Ricardo installation.

Hitherto, supercharging has not always proved satisfactory. The delivery rate falls off at low r.p.m. and the torque curve tends to be lifted after maximum torque, which occurs higher up the speed range than with normal aspiration. Thus, with some forms of supercharging, the engine may not pull well at low speeds, combustion may be incomplete at these speeds and fuel consumption is consequently adversely affected. Clearly, if supercharging is to be successful, the blower must deliver air at a rate always proportional to engine speed; this implies a blower having positive displacement, which in turn suggests cylinders and pistons.

Ricardo and Co. (Engineers) 1927 Ltd. recognised these desirabilities. The problem was how to make a piston type blower that would give a constant flow of air, tolerably pulsation-free, yet still be of reasonable cost and, since a multi-cylinder layout was indicated, have minimum internal friction.

In order to achieve a compact multi-cylinder blower, it was decided to adopt the *barrel* layout used for a Bristol engine many years ago. In this layout, the cylinders are disposed in a central ring, in the centre of which rotates a Z-crank. This crank drives a non-rotating wobble plate, which reciprocates the pistons. A bank of cylinders can be arranged on each side of the wobble plate, axially in line with one another. As a blower, the pistons can be also double-acting and those parts of the Z-shaft lying within the circle of cylinders can carry rotary valves. In this way, the Wellworthy-Ricardo blower, which has two banks of seven double-acting pistons, imparts 28 pulsations per revolution to the supercharge air, to give what is virtually a continuous flow.

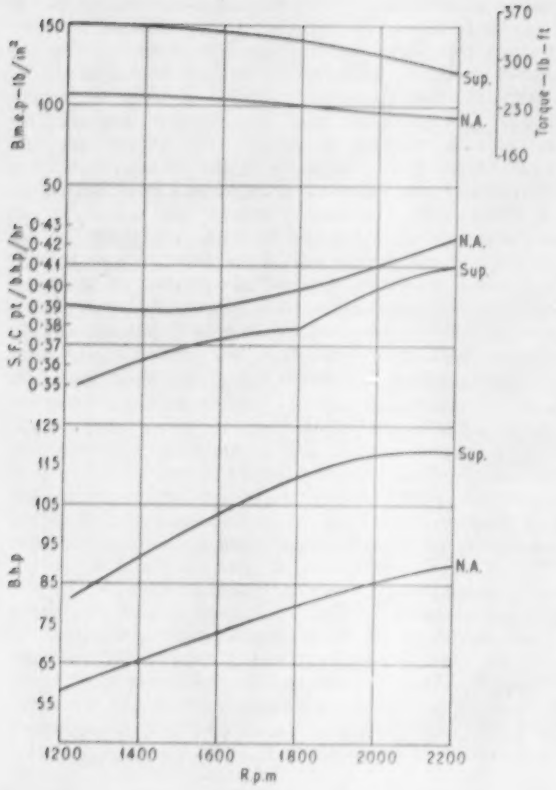
In a conventional piston type compressor, most internal friction is caused by drag of the piston rings on the cylinder walls. Ricardo and Wellworthy therefore decided not to use piston rings. The light alloy pistons of the supercharger work in their aluminium cylinder bores with 0·0035in diametral clearance. Experiments are now being carried out with 0·00225in clearances. Motion is imparted to the pistons through seven, long, double-ended, $\frac{7}{16}$in diameter piston rods, working in guides. The pistons are thus located centrally in their bores by the piston rods, each of which has a piston screwed on and locked by a Philidas nut at either end. Fourteen V-grooves are turned in the circumference of each piston to act as a labyrinth sealing. Attachment of the piston rods to the wobble plate is through a universal joint with hardened pins working in the eye of the Nitralloy forged rod and also on one another. The pin carried in the wobble plate, which is an aluminium alloy die casting, is an interference fit. Two bushes, spaced some 4in apart, support each piston rod. The bushes nearer the wobble plate are of Wellworthy W85 light alloy material, work-hardened by compression. These have a working clearance of 0·00075in. The outer bearings are lubricated by oil that seeps past the inner bearings and are of bronze, lined with white metal. They have a working clearance of 0·0005in.



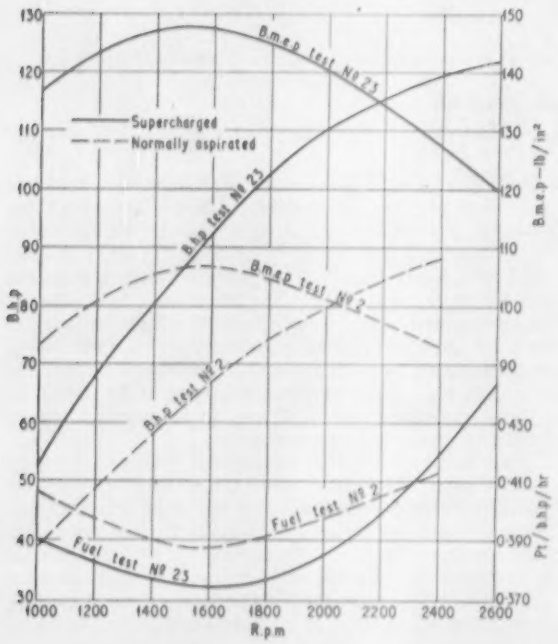
Wobble-plate assembly to mainshaft

Development of the wobble plate has reduced its weight by ½ lb. It is intended to experiment with a steel forging design at a later date. The action of the wobble plate is that of a figure eight. Torque reaction is taken at the bottom by a Lo-ex aluminium alloy slipper block working with a 0·002in clearance in a cast iron guide.

Two Hoffman 150ACD thrust ball bearings carry the wobble plate. The outer races are an interference fit in the aluminium wobble plate and a bronze annulus, $\frac{1}{32}$in thick, is interposed between the locating faces of the wobble plate and the outer race. These rings were found necessary to overcome an indenting effect during operation when the outer races were found to embed themselves in the aluminium as much as 0·007in after 25 hours of running at 4,000 r.p.m.



Comparative performance curves for direct injection, normally aspirated and supercharged engines. Above: curves for a 5·76 litre engine; below: for a 5·1 litre engine with the supercharged curves shown in full lines

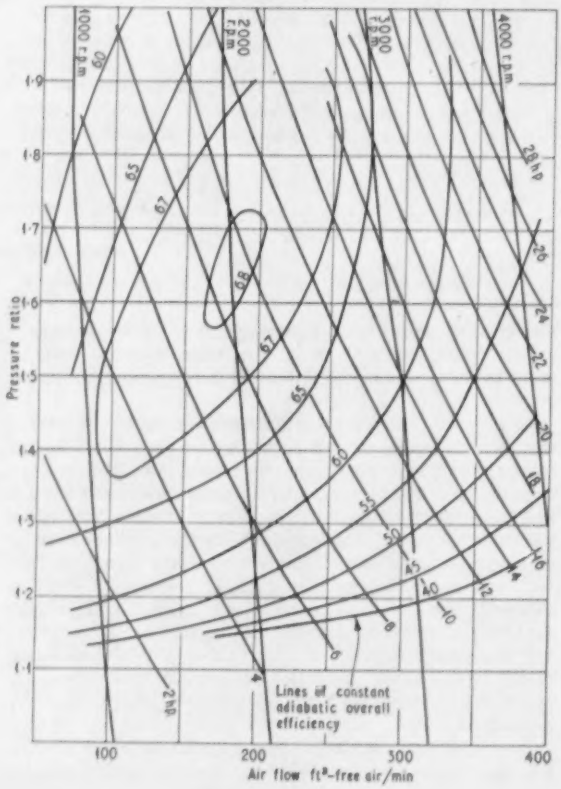


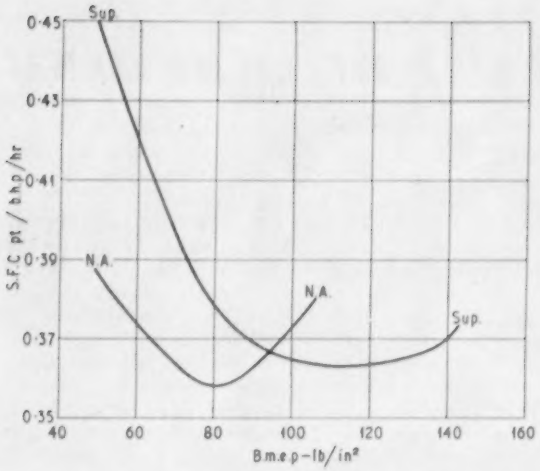
A preload of 0·001in is applied to the wobble plate bearings to allow for differential expansion of steel and aluminium parts as the blower reaches operating temperature when all bearings run at correct clearances. Two Timken 1994X taper roller bearings, straddling the cam which imparts the Z-crank action, are also preloaded when cold to an amount determined by feel. Woodruff keys secure the cam to the drive shaft, which is of En 33, heat treated to 50 ton tensile. The outer ends of the shaft carry the rotary valves, which are aluminium castings. Drive for the valves is from a tongued plate, keyed to each end of the shaft. Like the pistons, the valves require no lubrication, since they work with fine clearance in the supercharger body. Oil-free air is therefore delivered to the engine. A plain roller bearing at the drive end and ball bearings at the free end support the extremities of the drive shaft.

An internal lubrication pump of the eccentric and plunger type is provided. It meters oil through drillings to the various bearings. Oil is supplied from the engine lubricating system and the supercharger therefore eventually runs at engine oil temperature which is around 86 deg C. Besides the differential expansion problem, which has been a major problem in development by Wellworthy Ltd., the high operating temperature means that although the blower theoretically has an excellent adiabatic efficiency, some heat must inevitably be absorbed by the air in passing through the supercharger. It seems appropriate to wonder, therefore, whether this is not a case where the blower would be better for having a lubrication system independent from the engine.

Production of the Wellworthy-Ricardo supercharger is now under way at Wellworthy Ltd. One hundred units are to

Adiabatic efficiency curves for a supercharged engine





These curves show the effect of load on specific fuel consumption

be delivered to manufacturers and operators all over the country. The 3·25 litre model, which is being concentrated on at present, is suitable for engine sizes from 5 litres to 8 litres. A maximum delivery of 468 ft³ per minute at 4,000 r.p.m. is possible. Since the efficiency of the blower is fairly stable throughout its speed range, and because the maximum r.p.m. of diesel engines tends to decrease as they become larger, a wide range of engine sizes can be served by one size of blower. The larger the engine the faster the supercharger must be driven. For installation on existing engines, the most convenient form of drive is usually by triple V-belts from the crankshaft nose. For consideration as original equipment, it is presumed that a more positive drive, such as gears, can be arranged from the engine.

Power output on the bench has been boosted by as much as 58 per cent, corresponding to a b.m.e.p. figure of 164·7, before exhaust smoke becomes visible. This proves that the blower is working well within its capabilities when improving engine performance by 40 to 50 per cent. Bench tests on a 5·76 litre engine have shown that when torque is increased from 240 lb-ft to 346 lb-ft and power from 90·5 b.h.p. to 118 b.h.p., full load specific fuel consumption is improved from 0·387 pt/b.h.p.-hr to 0·35 pt/b.h.p.-hr. Part-load fuel consumption below 90 b.m.e.p. is not, however, as good as with normal aspiration. Therefore, it seems that to take full advantage of supercharging, the engine must be worked hard. Arduous conditions are mostly found in the goods vehicle and city bus service fields and it is fitting that two of the Wellworthy company's own fleet of transport vehicles have been equipped with Wellworthy-Ricardo superchargers in order to gain operating experience.

The two lorries, Leyland Comets, accommodate the conversion very neatly. The external appearance is unaltered, but leg-room on the mate's side has had to be curtailed by moving that part of the scuttle back to provide clearance for the supercharger. Triple V-belts drive the blower at a ratio of 1·42 times engine speed from a pulley on the front of the crankshaft. A new fuel pump with 8mm diameter plungers instead of 7·5 mm and equipped with a mechanical governor instead of the pneumatic type are the only major alterations to the specification.

Road test results confirm the test bench figures. Acceleration comparisons between a normal Leyland Comet and one equipped with a Wellworthy-Ricardo supercharger, both loaded to 12 ton 9 cwt gross, showed the latter vehicle to have some 50 per cent better performance. The results are as follows:

		Super-charged	*Unsuper-charged*
Through gears	0–20 m.p.h.	12 sec	18 sec
Through gears	0–30 m.p.h.	20·5 sec	32 sec
Top gear only	10–20 m.p.h.	13 sec	19·5 sec
Top gear only	10–30 m.p.h.	26 sec	38 sec

Timed climbs of a hill, with the same driver in each case, were made with each vehicle and here the normally aspirated lorry ascended in 2 min 18 sec while the blown version took 1 min 55 sec, in second gear low-ratio of the two-speed axle instead of first gear and high axle ratio for the unsupercharged Comet. Some improvement in the cooling arrangements of the supercharged vehicle seem desirable as boiling was evident after two or three climbs. Ambient temperature was 85 deg F and the cooling system was not pressurized. Both vehicles showed visible exhaust smoke at full throttle, but it is clear that smoke would be completely avoided by slightly derating the fuel pump. Operating experience over some 30,000 miles has shown the supercharged vehicle to return about 1 m.p.g. better than a normal vehicle when running fully laden. Empty running is not so economical.

The supercharged engine is quiet and smooth-running at part throttle and idling, owing to the presence of excess air under such conditions. Furthermore, supercharging has not altered the engine characteristics: it still pulls well at low speed, which proves that the pressure ratio is well maintained when down to 600 r.p.m.

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INERT GAS-SHIELDED ARC WELDING

British Oxygen Automatic Argonaut System Embodies New Method of Control

SINCE its inception in America during the war years the technique of gas-shielded arc welding has attracted considerable attention and has been subjected to continuous development. First used in the aircraft industry for the welding of thin magnesium and stainless steel, it is now extensively used in many industries in a wide variety of work. Helium was the inert gas initially employed, being passed to a nozzle enshrouding the tungsten electrode and flowing over both the hot electrode and the molten weld pool to shield them from oxidation by the atmosphere. In a few years the original D.C. arc was supplemented by a stabilized A.C. arc, argon had replaced helium as the protective gas and many other metals had been satisfactorily welded. The fact that flux was not required made the process particularly attractive for the welding of aluminium as the danger of entrapped flux was thereby completely eliminated. As this is an arc welding process, the welding heat is localized, the heat-affected area is limited, and consequently distortion is considerably less than when gas welding is employed. For many types of welds, particularly of heavy sections, a filler rod is either desirable or necessary. Manual welding is, therefore, a two-hand operation.

Alternative to the tungsten-arc system, the gas-shielded metal-arc system is more suitable and generally more economical for welding material thicker than 0·125in. From this it should not be inferred that it is unsuitable for thinner sections. Automatic welds can be made on 16 S.W.G. sheet metal if the parts to be joined are accurately jigged. The process uses a continuous, consumable, bare wire electrode and the metal is transferred across the arc in the form of a very fine spray at a high current density. As a consequence very high welding speeds can be attained. It is well established for welding aluminium, aluminium bronze, copper and stainless steel. This process was used on the fabricated light alloy tipper body shown in Fig. 1. More recently it has been proved to be particularly suitable for welding carbon steel and is now being more widely used in that field.

Equipment and supplies for both these processes are produced by the British Oxygen Co. Ltd., Bridgewater House, Cleveland Row, St. James's, London, S.W.1 under the names Argonarc and Argonaut respectively. The Company manufactures the inert argon gas, which can be supplied pure or with a small addition of oxygen; such admixtures have been found to stabilize the arc when welding mild steels. A mixture of argon with 2 per cent oxygen has been established as the standard shielding gas and is designated Argonox 2. Two further standardized mixtures are Argonox 1, particularly for stainless steel, and Argonox 5, employed for special applications. Too high a percentage of oxygen increases the rate of burn off and tends to lower the mechanical properties of the weld by reason of increased loss of elements, such as carbon, silicon and manganese, from the weld metal.

The Argonaut system has been commercially available for the past three years. Until recently welding was performed only manually by means of a gun requiring single-hand operation, see Fig. 2. With that equipment the welding wire is fed by an adjustable-speed motor drive, at a constant rate and the arc voltage is maintained constant by the principle of automatic adjustment through changes in the rate of burn-off with variation of the arc length.

The Automatic Argonaut system

The new Automatic Argonaut head, Fig. 3, makes possible fully automatic, high speed, production welding of metals of $\frac{1}{8}$in section and upwards. Its advantage lies in high welding speed, consistently smooth weld bead, and even and controlled penetration.

In contrast to the method employed for the manual gun, the automatic head maintains constant arc voltage by varying the rate of wire feed. Constant welding conditions are precisely established by automatic regulation of the speed at which the wire is fed into the welding arc. For this

Fig. 1. Light alloy tipper body completely fabricated with Argonaut welding by Roadstones Ltd., Dublin

Fig. 2. Manually welding lorry body with Argonaut gun

purpose the wire is drawn from the reel by means of a grooved feed roll driven by two electric motors through a differential gear mechanism, as shown in Fig. 4. The A.C. motor operates at a constant speed but the D.C. motor runs at a varying speed in response to signals from the arc voltage. Normally, the A.C. motor rotates in the opposite direction to the D.C. unit. Actuation of the "high-low" switch on the main control panel, however, reverses the A.C. motor to run in the same direction as the D.C. motor and provides a range of higher feed speeds suitable for the smaller diameter wires.

The welding unit comprises a head housing the wire feed mechanism, a water-cooled barrel carrying the water-cooled gas nozzle, Fig. 5, a wire reel casing assembly bracketed to the head, a casing to conduct the wire from the reel to the feed mechanism, a main control panel, and an operator's remote control box. Additionally, there will be a motorized tractor to carry the head along a track, a motorized work positioner, or both these units according to the nature of the work, or the range of work, to be undertaken. These devices will move either the head or the work so that the weld follows the seam.

Controls

Location of the control panel, carrying the main voltage control, the wire feed "high-low" switch, and the polarity switch, can be arranged to suit convenience. It can be mounted on the power source on the welding head tractor, as shown in Figs. 3 and 8, or on the structure of the welding fixture. Also mounted on the panel are meters indicating the arc voltage and welding current. These are used mainly when setting-up and when checking for optimum welding conditions.

On the remote control box six controls are provided so that the operator can exercise complete control without leaving his station. They are:—

1. Fine adjustment of arc voltage.
2. Argon purge of gas supply line and arc shroud before striking the arc. This control also starts the water cooling system.
3. Inching feed of welding wire.
4. Tractor start and stop, for positioning only, prior to welding.
5. Lift of head away from work. Maximum movement 6in. This control can also be arranged to traverse or rotate the work.
6. Welding switch, bringing in all items, including the tractor.

Incorporated in the control system is a water pressure switch to ensure that welding cannot be started unless there is a specified pressure in the cooling system, and an initial slow down-feed for the wire to give smooth arc starting. Also included is a stub burn-off control to obviate the possibility of the welding wire freezing into the weld pool when an operation is completed.

Power unit

A 600-amp composite dry rectifier has been designed specifically for use with the Automatic Argonaut head. It includes a transformer with primary tappings for 360, 380, 400, 420 and 440-volt, 3-phase, 50-cycle supply, and a dry plate selenium type rectifier. This unit is fan cooled and is equipped with an automatic device to give protection in the event of a failure of the fan motor. Remote control of the complete range of welding currents from 120 amp to 600 amp is effected by means of a rheostat which controls the current to a magnetic amplifier. A single-pole 600-amp D.C. welding contactor with a 115-volt A.C. coil is remotely controlled.

Operational capacity

The currently available Automatic Argonaut equipment is designed to handle 600 amp D.C. continuously and to feed either "hard" or "soft" wires. In the first category 0·035in, 00.045in, $\frac{1}{16}$in, and $\frac{5}{32}$in diameter stainless steel, copper, aluminium bronze, and carbon steel wires and, in the second group, $\frac{3}{64}$in, $\frac{1}{16}$in, $\frac{5}{32}$in and $\frac{1}{4}$in diameter aluminium and light alloy wires are used.

Two ranges of wire feed speeds are provided. On the "low" switch position speeds of from 80 to 350in/min are available and on the "high" switch position speeds of from

Fig. 3. The new Automatic Argonaut head set up for logitudinal seaming of heavy steel tubular component

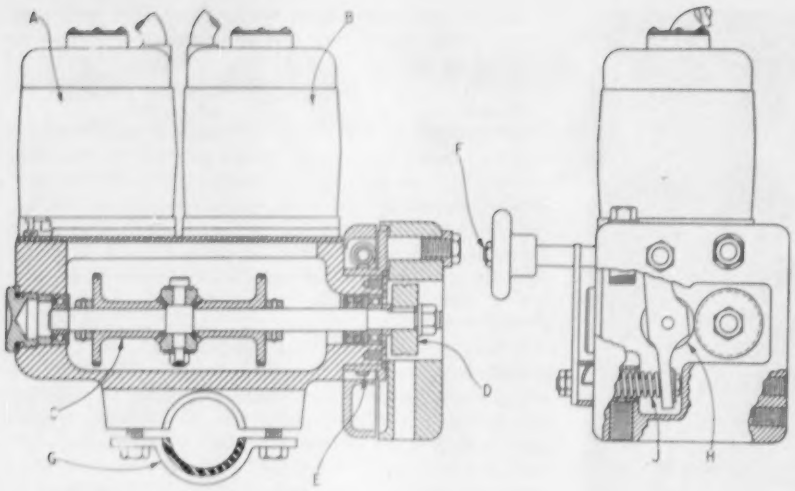


Fig. 4. Automatic head with differential wire feed

A—A.C. motor, B—D.C. motor, C—differential assembly, D—wire feed roll, E—worm wheel assembly, F—worm shaft, G—head mounting clamp, H—wire pressure roll, J—pressure roll spring

150 to 450in/min are obtained. Feed speeds are varied by rheostat control. Should exceptionally high speeds be required, special gears can be supplied to raise the maximum speed to 750in/min. Speeds available in the two ranges by the selection of different diameter feed rolls are shown in Figs. 6 and 7, together with indications of typical speeds for wires of specific diameters in various metals. A change-over from one wire to another may necessitate the change of wire guides, feed rolls, contact tubes and other fittings.

Tractor unit

The tractor carrying the welding head can be supplied to give speed ranges, up to a maximum speed of 750 ft/hr, to meet specific requirements. A full range of movements for positioning the welding nozzle is provided in the mounting. The gearbox is clamped on a horizontally arranged tubular support on the tractor carriage and can be pivoted about this to give lead or lag, usually about 20 deg, to the barrel. It can be raised or lowered vertically by means of a screw gear and cross-traversed by rack and pinion. The face plate carrying the barrel can be pivotally adjusted in a transverse plane by a worm gear, see Fig. 4, to set the nozzle at a suitable angle for fillet welding.

Gas and water supplies

Shielding gas and cooling water connections to the head are by $\frac{1}{16}$in diameter hoses. A water supply providing a flow of 2 pints per minute is required for the welding barrel and the gas nozzle. It is advisable that the incoming water is filtered. The line pressure needs to be about 25 lb/in^2 as a minimum but should not exceed 40 lb/in^2, and the drain hose should be as short as possible to minimise back pressure. The water is delivered to the inner barrel carrying the welding wire and then passes to the shroud on the end of the outer barrel.

Gas supply may be varied in respect of pressure and volume to meet the requirements of specific operations. A typical supply when welding steel of medium thickness would give an approximate consumption rate of 45 ft^3/hour for continuous operation.

Gas and water solenoid valves are energized by the purge switch on the control box and controlled by a synchronous motor timer housed in the main control panel. This timer enables the period that gas and water will flow after a weld has been completed to be adjusted from zero to 15 seconds. Another timer provides for starting the water flow and purging the line for a minimum of 2 seconds between the operation of the welding switch and the starting of the wire feed roll at the commencement of a welding operation.

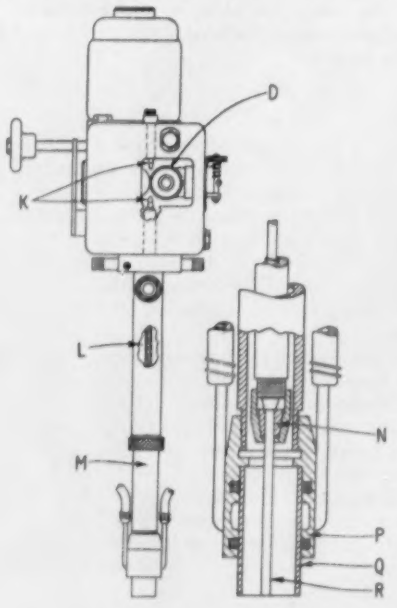
Steel welding

Research and development work undertaken to produce a general-purpose wire for use with the Argonaut system is still being continued. To date, the most successful wire has the designation A.675 and this wire is at present being imported for use in Britain. The specified analysis is:

Carbon	0·07–0·14 per cent	
Silicon	0·30–0·60 ,, ,,	
Manganese	0·80–1·10 ,, ,,	
Sulphur	0·025 ,, ,,	maximum
Phosphorous	0·030 ,, ,,	maximum

Fig. 5. Water-cooled gas nozzle assembly

D—wire feed roll, K—wire guide sleeves, L—liner, M—insulating tube, N—contact tube collet, P—gas nozzle assembly, Q—gas nozzle tip, R—contact tube



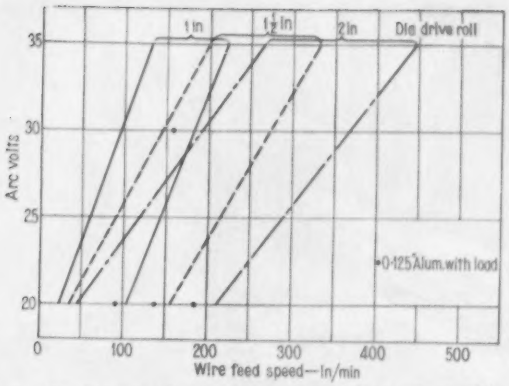


Fig. 6. "Low" range of wire feed speeds with feed rolls of different diameters, showing typical speeds for 0.125 aluminium wire

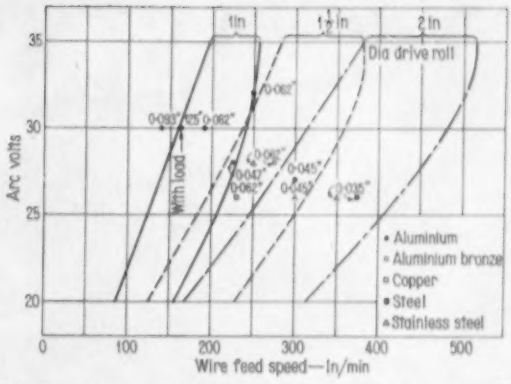


Fig. 7. "High" range of wire feed speeds. Normal operating speeds for wires of various diameters in different materials are indicated

Actually the wire used for a series of welding tests was found to have the following composition:

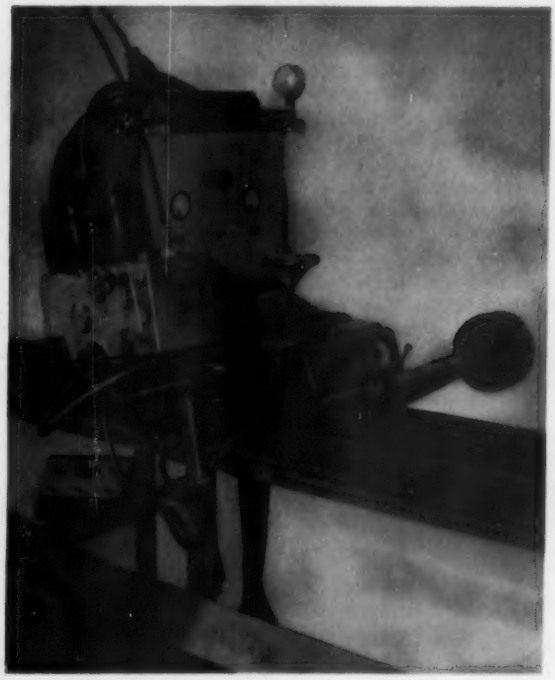
Carbon	0·14	per cent
Silicon	0·42	,, ,,
Manganese	0·97	,, ,,
Sulphur	0.021	,, ,,
Phosphorus	0·012	,, ,,

The deposited weld metal analysis depends upon several factors, but particularly on the amount of oxygen included in the shielding gas and on the arc energy input to the weld, that is, the current : voltage ratio. In this instance the weld metal composition was:

Carbon	0·11	per cent
Silicon	0·31	,, ,,
Manganese	0·81	,, ,,
Sulphur	0·021	,, ,,
Phosphorus	0·018	,, ,,

During welding, the carbon content changes only slightly but the silicon and the manganese are significantly reduced.

Fig. 8. Seaming a box-section chassis frame member in 16 S.W.G. material. The operator's control box will be seen resting on the fixture framing



Approximately 10 per cent of these elements are lost in a pure argon shield and 15 per cent in a shield of Argonox 2 per cent. The transfer efficiency of these metals is reduced with higher energy inputs.

The mechanical properties of the weld metal were:

Ultimate tensile strength	34.2 ton/in²
Yield strength	26.8 ,,
Elongation in 2in	26 per cent
Reduction of area	40 ,, ,,
Brinell hardness	180

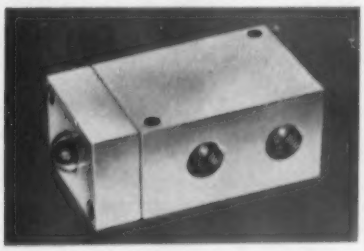
Basic welding conditions

In evaluating a new operation, the welding speed is an unknown factor. Basic welding conditions have been established, however, and these can be relied upon to produce satisfactory butt or fillet welds with either manual or automatic equipment. These basic conditions are :

Wire size, in	0·045	1/16	1/32
Current amps	225	340	450
Arc voltage	26–28	27–29	27–29
Argonox 2, ft³/hr	50	50	50
Wire feed, in/min	279	232	144
Deposition rate, lb/hr	7·3	12·2	18·0

Making use of the basic conditions, sample welds can be made and from these an appropriate speed can be determined.

Air Control Valve

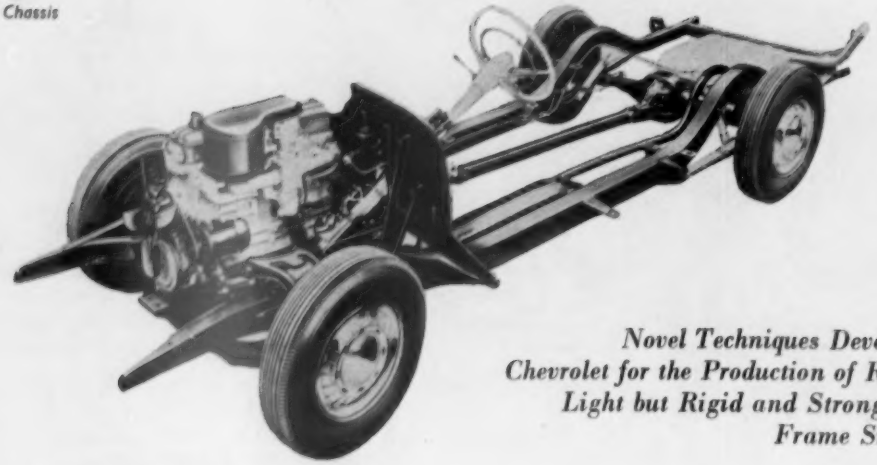


A new addition to the range of Red Ring air equipment manufactured by Stuart Davis Ltd., Much Park Street, Coventry, is the type P.100 valve illustrated. The valve is instantaneous in operation and allows for full port flow. The brass spindle, on to which are moulded the poppet faces, requires a movement of only 1/16in to open or close the ports. Spring pressure holds the poppet to one machined face and the valve is actuated by depressing the end of the plunger.

Servicing can be carried out without breaking pipe connections. The spindle assembly, the only moving part, can be withdrawn after removing the cover by releasing two screws. Overall dimensions are 1¼in × 1¾in × 2¼in.

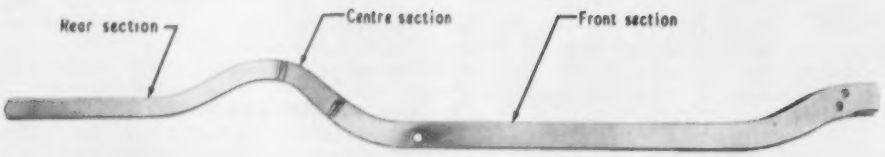
FRAME MANUFACTURE

The Chevrolet 1955 Chassis



Novel Techniques Developed by Chevrolet for the Production of Relatively Light but Rigid and Strong Chassis Frame Side Rails

Fig. 1. The frame side rail is fabricated from three rectangular box sections



BEFORE 1955 Chevrolet passenger car frame parts were produced in one plant, and were later assembled at various plants throughout the United States of America. It was felt however, that closer tolerances could be maintained if the complete frames were produced in one manufacturing unit, and this, of course, would reduce the problems encountered in assembly. This procedure was adopted for 1955 Chevrolet models, which incorporated major changes in body styling, engine design and suspension systems.

Changes of this character inevitably entailed a change in frame design and in the number and location of cross members and support brackets. It was decided that the new frame should be based on side rails of rectangular section. Details of the manufacturing methods for the new frame were recently given to the Society of Automotive Engineers by Godfrey Burrows, of the Chevrolet-Flint Frame and Stamping Division of General Motors Corporation.

A rectangular section for the side rails was adopted because of its strength and rigidity, and also because it would provide sections of adequate depth and stiffness at critical locations and give desirable side-wall surface area for mounting body brackets. It was also decided that the new design would break away from the existing practice in which a box-type girder was fabricated by lap-welding two channel sections. The side rail finally adopted comprises front, centre and rear sections, as shown in Fig. 1.

Owing to strength, rigidity and weight considerations, it was not possible to design the side rail to be of constant depth and width and perfectly straight throughout its length. The design specification called for the front section of the side rail to be approximately 101in long before the front end and rear ends were bent. For a length of 15½in at the forward end of the front section, the width is 2.88in and the depth 5.62in; this rectangular section then tapered to a width of 4·00in and a depth of 4·50in for the remainder of the length of the front section. The rectangular dimensions at the forward end of this section were necessary to provide a strong section at the point where the bending moment on the frame would be maximum.

The rear section has a constant width of 2·75in and depth of 3·50in throughout its 51in length. It required two bends at its forward end to provide a "kick-up" for clearance over the rear axle. The centre section, 13in long, was designed to form a smooth transition between the front and rear sections. Throughout its length, the side rail was to have a wall thickness of 0·090in.

In general, the proposed method for manufacturing the frame side rail called for the front and rear sections to be fabricated from circular tube, which in its final form would be rectangular in shape. The tube was to be formed from strip steel in a tube mill, and the butt seam welded by the resistance seam welding process. After the welding, the tube was to be drawn through forming rolls designed to produce a rectangular section of the specified dimensions. It was calculated that the maximum speed for this method of forming would be 150 ft/min. The centre section was to be fabricated from two steel pressings welded together by the submerged arc process.

Considerable investigation was necessary to determine the most practical method for producing a rectangular section side rail with the minimum of expensive tooling. Finally, the following operation sequence was adopted:—

(1) Tube mill
(2) Resistance seam welding
(3) Rectangular forming
(4) Cut off to length
(5) Section transformation on front length
(6) Bending of front and rear lengths.

Tube forming is carried out in two standard tube mills, one for the front and the other for the rear section of the side rail. It was, of course, necessary that the diameter of the tube produced in each mill would be held to close tolerances to ensure that a rectangular section of 4·00in × 4·50in for the front and 2·75in × 3·50in for the rear would be obtained

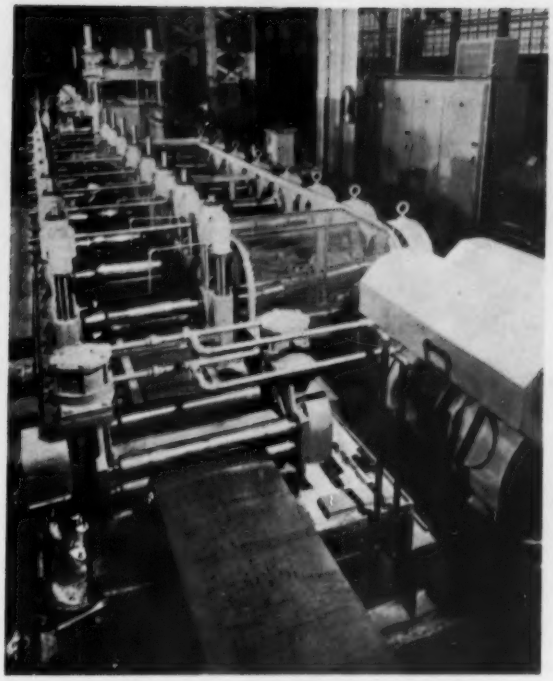


Fig. 2. At the first operation flat strip for the side rail is formed into circular tube

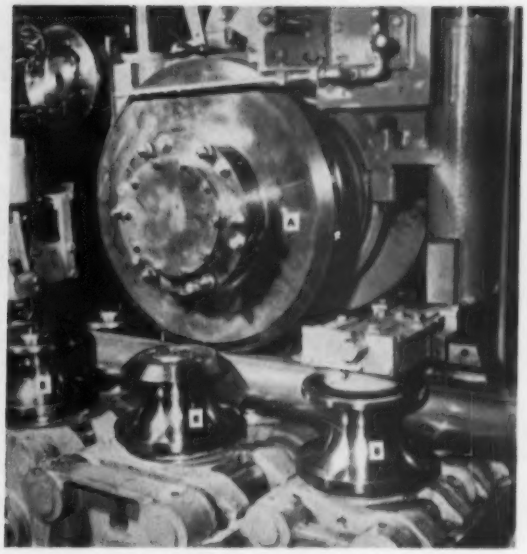


Fig. 3. Immediately after leaving the final forming roll, the tube is resistance seam welded

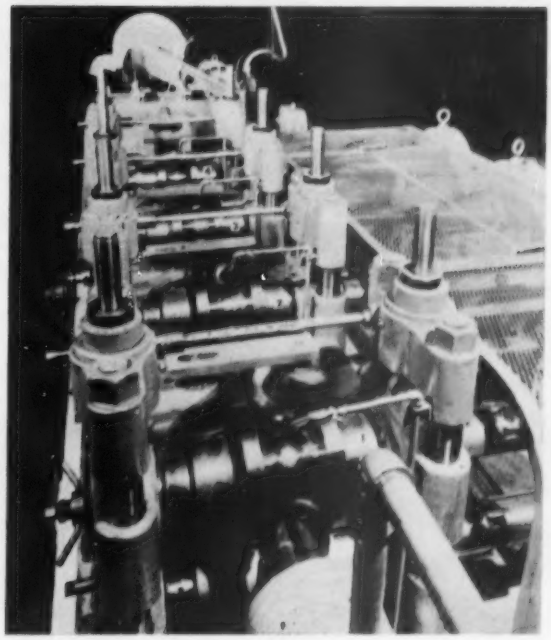


Fig. 4. The welded tube passes through four forming rolls and thence to a turk's head for final forming

after the welded tube had passed through the rectangular forming rolls.

Three points of major importance had to be determined before actual production could be started. They were:—

(1) The number of passes required in the forming roll equipment to produce a circular tube.

(2) The width of strip steel to give a tube of the specified diameter.

(3) The amount of metal to allow for "burn off" during the resistance seam welding operation.

It was realised that the design of the forming roll equipment would affect the width of the strip, since some designs would stretch the material while others would tend ot upset or thicken it. When all the design details had been settled, forming roll equipment with six passes or stations, from the entrance pass to the final one before welding, was mounted in each of the standard tube mills. One of the mills is shown in Fig. 2. Experimental runs were carried out on short lengths of strip steel until the correct width for each tube was established.

From the last forming roll station in the tube mill, the cylindrical tube passes direct to the resistance seam welding station. During the continuous welding operation, the tube is supported by guide and pressure rolls on each side to maintain the circular shape and to provide sound fusion at the junction where welding takes place. Two rotary electrodes are used, one on each side of the junction. They apply a constant pressure to bring the two edges into contact and cause an upsetting of the metal at the point of fusion. Fig. 3 shows a welding station. The outside or flash or upset is removed by a cutting tool which is in contact with the tube at the weld joint. The current required to produce the necessary heat at the point of fusion is provided by a welding transformer that has a rated capacity of 250 KVA, an output of 200 KVA and a secondary current capacity of 57,000 amps. The speed of the resistance welding operation is dependent upon the output from the transformer, the speed of tube travel through the mill and the thickness of the tube.

From the welding station, the tube passes through a series of four forming rolls and then through a "turk's head", a two-station unit with four rolls ground to the desired face contour at each station. The final transformation to rectangular section is effected in the turk's head. The sizing roll immediately before the turk's head is used to allow a more gradual breakdown of the tube, with less possibility of a misformed shape and also to reduce the

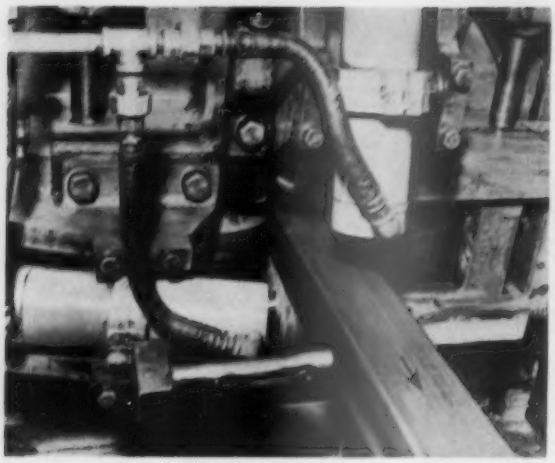


Fig. 5 The rectangular tube leaving the turk's head

Fig. 6 (below). The change in cross section affected at the operations illustrated in Figs. 3 and 4.

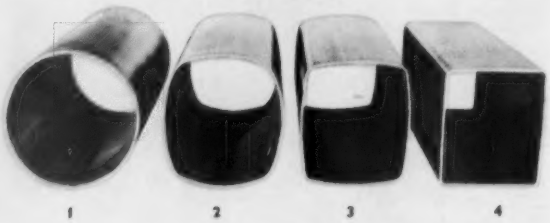
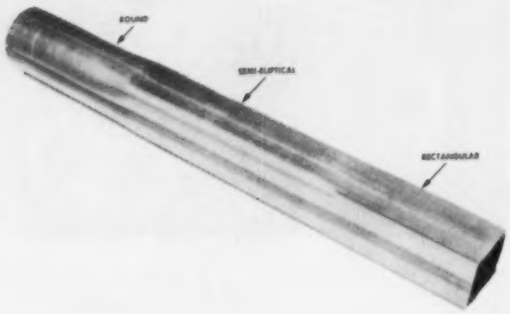


Fig. 7 (below). The transformation of the tube from round to semi-elliptical and to rectangular



severe abrasion on the tube. Fig. 4 shows the four sizing rolls, Fig. 5 the tube emerging from the turk's head, and the gradual transformation from circular to rectangular section is shown in Figs. 6 and 7.

A "flying saw" unit, see Fig. 8, is used to cut the continuously moving rectangular rail to the specified length. The flying saw unit clamps and travels with the moving rail. During this travel the rail is cut to the specified length. The cut-off stroke of the saw is initiated when the rail strikes the "target" A shown at the extreme left of Fig. 8.

As was stated earlier, the design specification calls for the forward end of the front section to have a width of 2·88in and a depth of 5·62in for a length of 15¼in. This rectangular section then tapers for a length of 14$\frac{3}{16}$in back to the 4·00in × 4·50in section produced in the turk's head. Considerable experimental processing was carried out to develop a method that would effect this section transformation efficiently and accurately with the minimum of expensive tooling. Finally, the tool shown in Fig. 9 was developed for the section transformation. Essentially this tool comprises two expanding units. The front expanding unit, shown at the right of the illustration has as its main components a movable centre wedge (*a*) and two side shoes (*b*). The rear expanding unit is arbor mounted and its main components are an adapter (*c*) two flappers (*d*) and two transition side shoes (*e*).

This tool is mounted in a specially designed, hydraulically operated machine, which has two fully automatic magazine-type loading stations, shuttle-type cross-feed and a central work station. The machine is shown in Fig. 10. This illustration shows at A one of the loading magazines, the

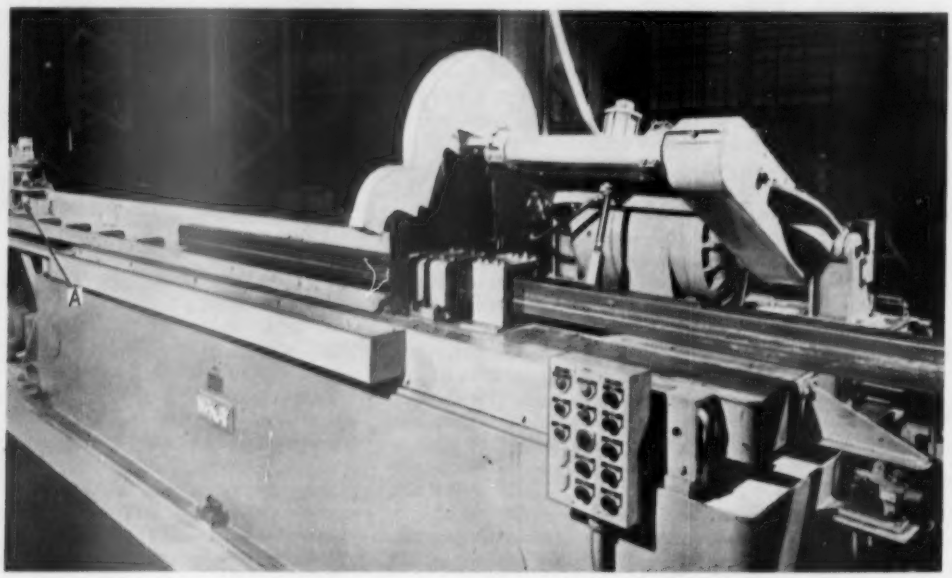


Fig. 8. The flying saw cuts the tube to specified length

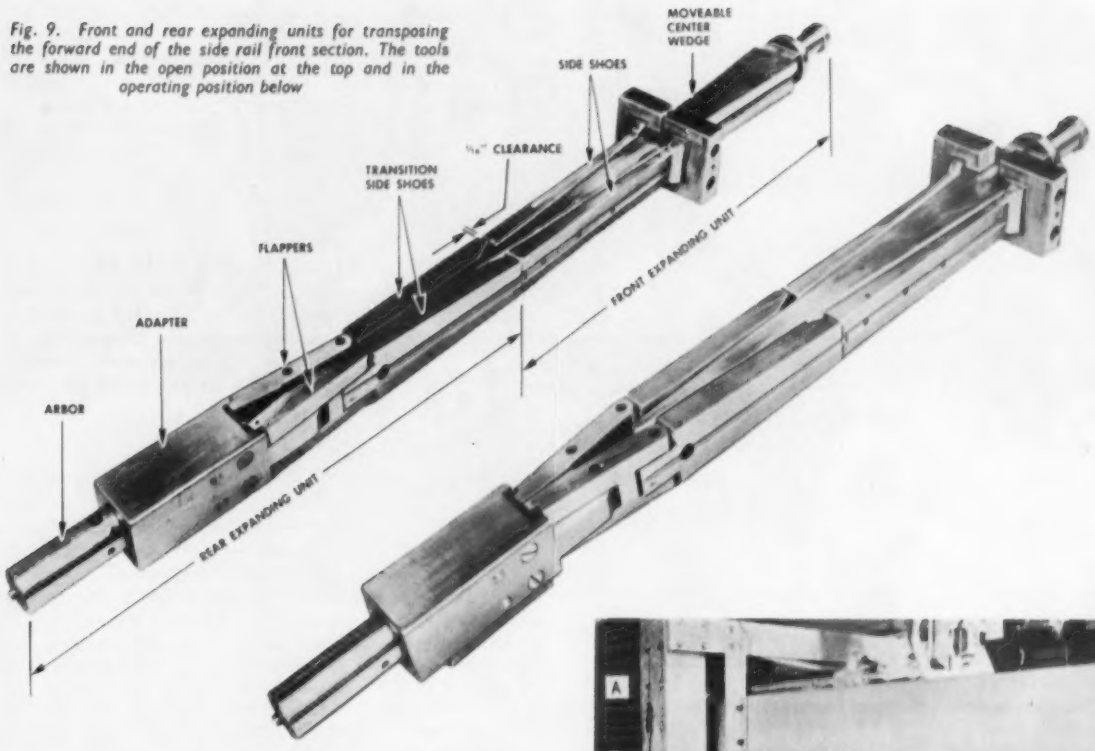


Fig. 9. Front and rear expanding units for transposing the forward end of the side rail front section. The tools are shown in the open position at the top and in the operating position below

other is at the far side of the machine. A side rail ready for feeding forward over the arbor-mounted rear expanding unit is shown at B; there is a similar rear expanding unit at the other side of the machine. Once a tube has been passed over one or other of the arbor-mounted rear expanding units, the unit and the tube are shuttled across to the mid-position to be held by the clamp D. When clamping is effected, the forward expanding unit is advanced to effect the section transformation. A tube ready for the entrance of the forward expanding unit is shown at E. Fig. 11 shows the same machine with a completed tube at F and a tube at G ready for removal to the working position. After withdrawal of the front expanding unit, the tube E is moved to the far side of the machine where it is stripped from the rear expanding unit.

Approximately 120 tons of hydraulic pressure is required to actuate the movable centre wedge of the front expanding unit from the open to the operating position. To remove the front expanding unit from the rail when this operation is complete requires a pressure of approximately 50 tons. This is only to start the initial movement. After a movement of approximately $\frac{1}{4}$in, the power required falls rapidly and the rail is easily stripped from the tools.

Front and rear section bending

Cold bending operations are required on both the front and rear sections of the side rail. The operations for the rear section are relatively easy, since this section is of constant width and depth and requires only two bends. For the front section, however, five bends are required, four in the transposed area and one at the rear end of the section. These bending operations are more complex because there is no separation between the bends in the transposed area. On the contrary, there is actually a bend on a bend, with the tangent of one bend overlapping that of another.

It was realised that to perform the bending operations

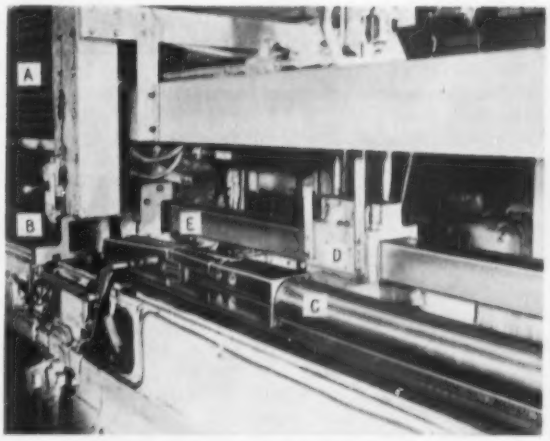
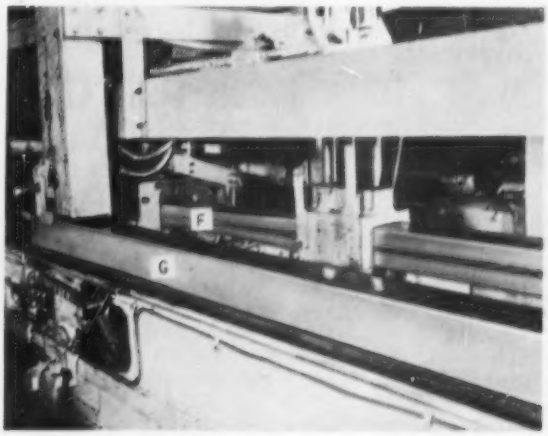


Fig. 10. The rear expanding unit ready to receive a tube from the magazine feed

Fig. 11. For transposition, the tube is moved to a mid-position for insertion of the front expanding unit



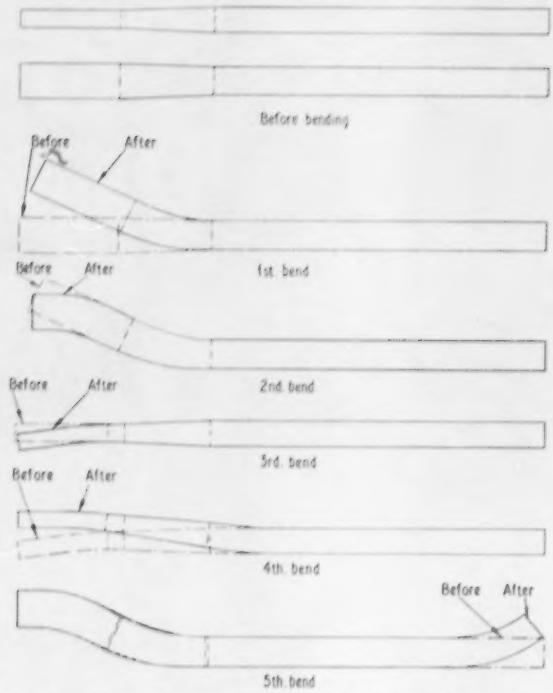


Fig. 12. Five bending operations are carried out on the front section

rail are sprayed with drawing compound. For the first bending operation on the front section it is necessary to use an expanding mandrel with internal articulation because of the changed inside dimensions after re-form. This mandrel is shown in the collapsed and operating positions in Fig. 13. Essentially, it comprises two outer mandrel sections, A and B, and a primary articulated section, C, which acts as a wedge. The mandrel is inserted into the tube in the collapsed position, and after entry for the correct distance, the centre mandrel C is pushed forward to expand the tool to fit the inside form of the tube.

Another interesting mandrel is used for the third bend on the side rail front section. This tool has two articulated sections as shown at A and B in Fig. 14. For insertion in the tube, the mandrel is in the condition shown at (*a*) in Fig. 14. After insertion, secondary actuation positions section A on section B to expand the tool to fill the inside of the tube.

Centre section

The centre section of the side rail is designed to form a smooth transition between the front and rear sections. Originally it was decided to form the centre section from a cylindrical tube in the manner used for the front and rear sections, but owing to the abrupt taper required, it was not possible to expand its relatively short length to the required dimensions because of excessive stretch. It was therefore decided to form the centre section from two pressings, one right- and the other left-hand, to be joined by submerged arc welding.

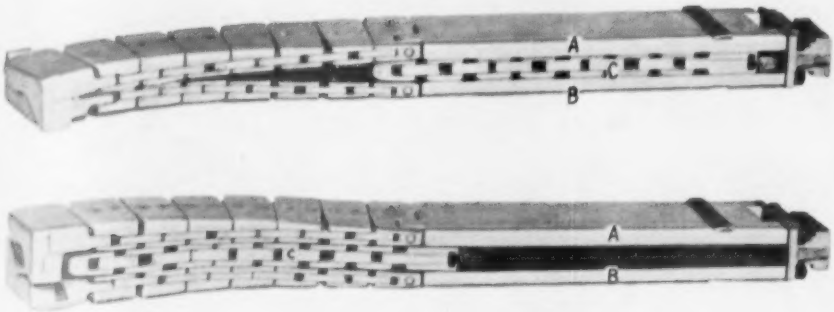


Fig. 13. The articulated mandrel for the first bend shown in the open position above and the operating position below

successfully, the inside area of the rail would have to be filled completely, or at least almost completely, by the bending tool. For this reason it was decided that articulated mandrels would have to be used. The outside diameter of the cylindrical tube as formed in the tube mill is held to close limits for both the front and rear sections. On the other hand, the dimension of the inside diameter may vary appreciably, owing to the commercial tolerances on purchased coil-strip material. In view of this, the articulated mandrels are designed for use with the minimum internal area, but at the same time to be suitable for performing efficiently in relation to the maximum internal area with a minimum of wrinkling on the outside surface.

Each bend on the forward end of the front section requires a specially designed articulated mandrel, and it is not possible to use the same mandrel design for two different bends. It is, however, possible to use the same mandrel design for the two bends in the rear section. Special machines with clamping dies and suitable tooling were built for these operations. Each bend is performed on an individual machine. The bending sequence for the front section is shown in Fig. 12.

Before any bending is carried out the inside walls of the

Side rail assembly

The complete side rail of front, centre and rear sections, is fabricated by resistance welding. Before welding is carried out, it is necessary to perform two important pre-welding operations. It is necessary accurately to size the mating ends of the sections and to insert a spacer in the end of each mating section. The quality of the weld is dependent upon the accurate sizing of the mating ends. This makes the sizing critical and accurate checking is necessary.

In operation, one section of the side rail is placed on a stationary platen, and its mating section is placed on a moving platen. At a pre-set stage in the welding cycle, the secondary current of the welding machine transformer is automatically cut off. The moving platen continues to move forward until the heated edges of each rail section are forced together with sufficient pressure to make a strong bond. The amount to allow for "burn off" in the length of the rail during the welding operation is taken into consideration when the rail is cut to length. In the welding sequence, the front section is first welded to the centre section, and this completed section is then welded to the rear section.

To complete the fabrication of the frame, the front and rear cross members and the various brackets are attached

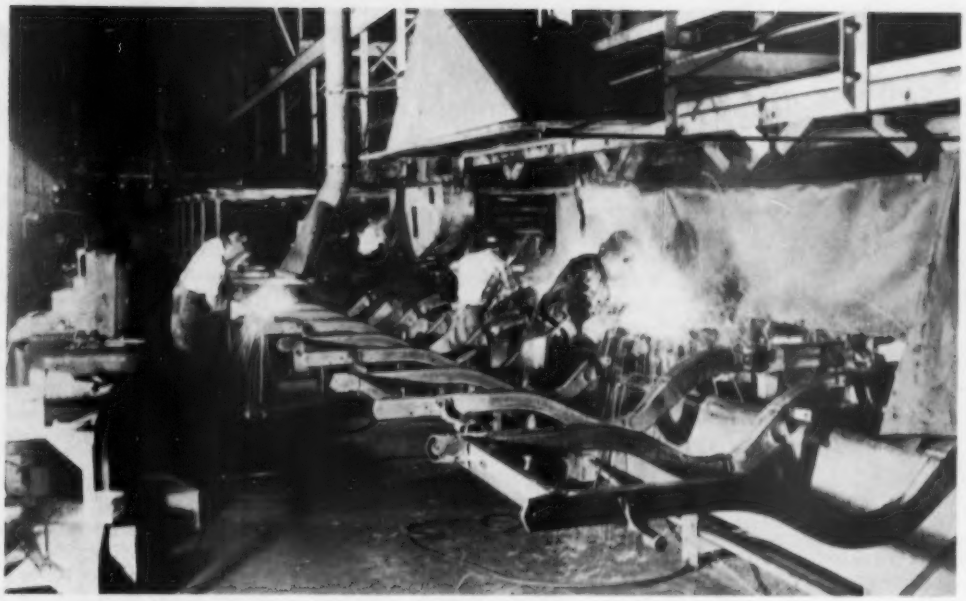


Fig. 15. The chassis frame welding conveyor

by manual arc welding. The work is carried on a conveyor that is so designed that all the welding is done in down-hand position. As the frame progresses along the conveyor, it is automatically turned through 90 deg in a clockwise direction at four different points. The final assembly conveyor is shown in Fig. 15.

After the frame has been assembled and all the welding completed, the necessary holes are pierced in all the body brackets. The frame is conveyed to a walking beam which carries it to a point directly over the piercing unit. It is then lowered into the holding fixture, which is an equalizing unit incorporated in a hydraulic piercing machine. This unit ensures that the frame is securely held in the correct position. The piercing machine comprises a number of accurately located, hydraulically operated "C" type guns, each of which contains a punch and die mounted on a common base.

The frame is rigidly positioned on locators mounted between the "C" type guns. This acts as a check on the accuracy of the frame, since if the frame does not rest automatically fully on all the locator, owing to body bracket misalignment or other causes, the need for further inspection is indicated. All the body brackets on the frame are pierced simultaneously.

When piercing is completed, the frame moves through a special three-stage washer. From the washer, the frame is carried by conveyor to the final flow-coat paint operation. These operations are all effected automatically. After the painting, the frame is dispatched to one or other of the various Chevrolet passenger car assembly plants.

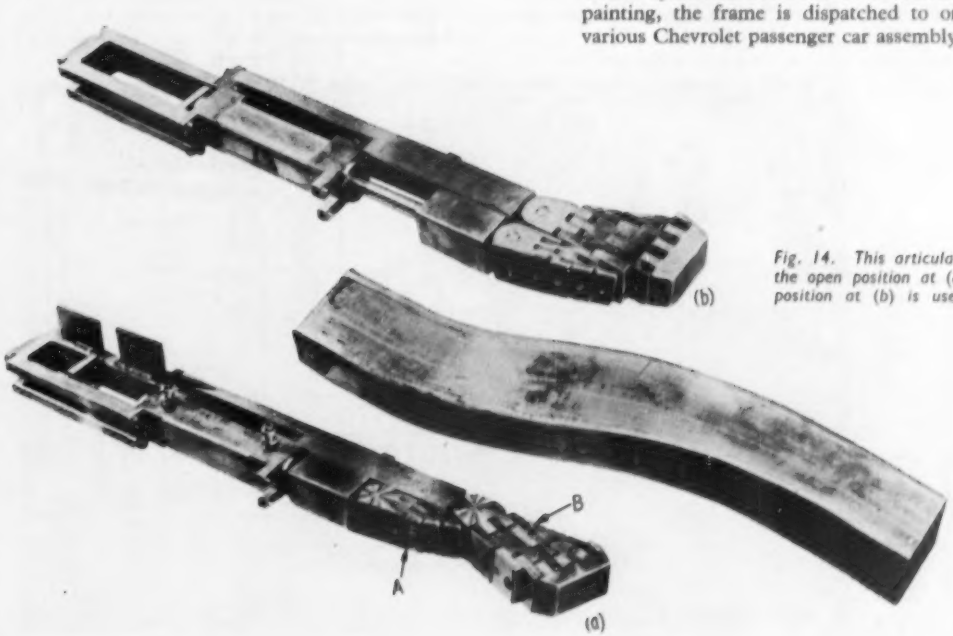


Fig. 14. This articulated mandrel, shown in the open position at (a) and in the working position at (b) is used for the third bend

Hardening Transmission Gears

Birlec Continuous Gas-Carburizing Furnace at E.N.V. Engineering Co. Ltd.

FOR about forty years the E.N.V. Engineering Co. Ltd. has specialized in the production of gears and its well-equipped plant at Hythe Road, Willesden, London, N.W.10, is one of the largest on this side of the Atlantic. Since the introduction of spiral bevel and hypoid gears, particular attention has been given to the production of those types and at present they constitute a substantial portion of the total output. Currently, production includes gearboxes and final drives for automobiles, passenger and commercial vehicles, agricultural tractors and machines, locomotives and railcars, gears for internal combustion engines and gas turbines, and large spiral bevel and hypoid gears up to about 6 ft diameter for heavy industrial and marine drives. The overwhelming majority of these gears are of alloy steels, carburized and quenched after gear cutting. Exceptionally large gears which cannot conveniently be treated in this manner are flame hardened on the teeth by the latest type of Gleason machine.

Since a very high standard of physical properties must be maintained and distortion must be held to a minimum, heat treatment is a vital link in the manufacturing process. Spiral bevel and hypoid gears, and also some types of cylindrical gears, present special problems in this respect as the teeth are developed to give a localized contact and thus avoid load concentration at the tips and ends in service. In case-hardening, some change of tooth shape is unavoidable and due allowance for this must be made during initial cutting. Heat treatment is applied after costly machining operations on expensive material and, consequently, the economics of production, as well as the quality of the product, makes it imperative that no effort is spared in the attempt to control distortion. The aim is to ensure consistency so that a minimum stock allowance can be made during the initial cutting. Pursuing this policy, heat treatment processes at the E.N.V. plant have for many years been under the control of a laboratory equipped and staffed to investigate problems associated with the production of casehardened gears.

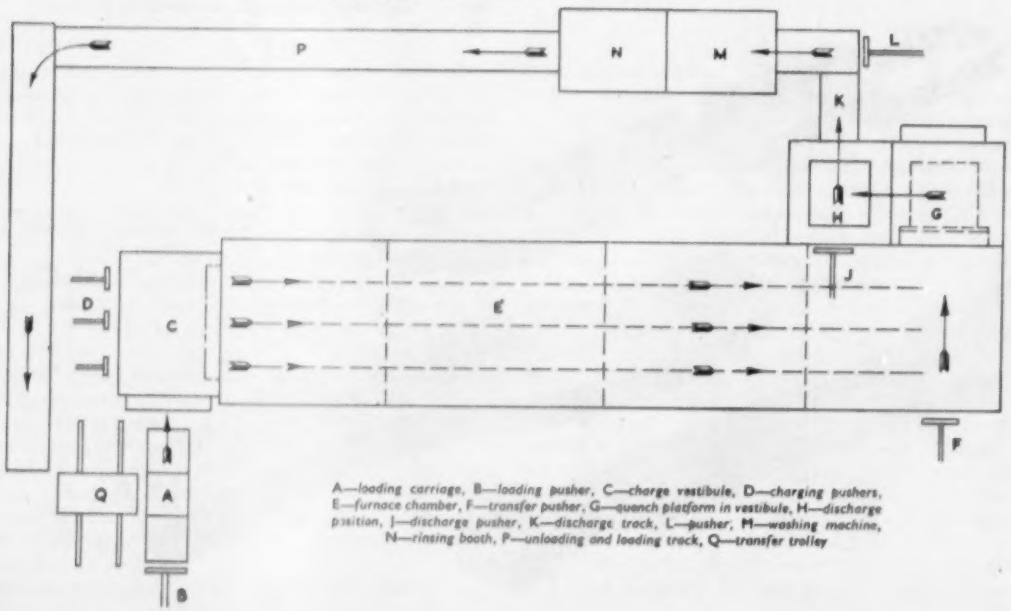
Conventional methods of pack carburizing and quenching by oil bath or under presses were long used and are still employed, particularly for special gears which require individual treatment. Pit type gas carburizing furnaces have been used for batched work for many years. The good results obtained by this method prompted the investigation of continuous gas carburizing. In addition to the economic advantage offered, the increasing use made of continuous processes, particularly in America, had indicated that it would be the most satisfactory treatment for the consistent production of gears.

It was this consideration, in addition to the economic advantages likely to be realized, that influenced the decision to install a continuously operated, automatically controlled, gas carburizing furnace. The Firm's metallurgists collaborated with the design team of Birlec Ltd., Tyburn Road, Erdington, Birmingham, to evolve the furnace illustrated.

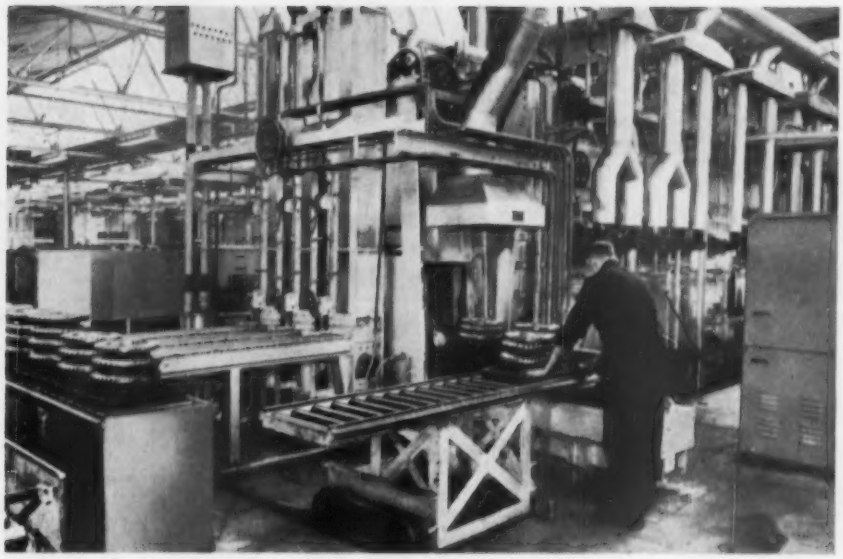
Features of the design are the high order of mechanization, the automatic control of operations on a timed cycle, and the versatility in operation. An important factor with respect to versatility is the provision of three tracks in the furnace along which work can be progressed at different speeds in order to produce different depths of case.

Experience with pit type furnaces had shown that while a satisfactory carburizing atmosphere gas could be prepared from town's gas, the composition of gas from the supply mains was subject to considerable variation. This variation would militate against the consistency in operation which was the prime objective of the new furnace. Furthermore, the sulphur content of town's gas is higher than is desirable and one or two stages of purification are necessary to reduce it. Accordingly, it was decided to produce the furnace atmosphere from propane which is commercially available

Layout of Birlec continuous gas-carburizing furnace



A—*loading carriage*, B—*loading pusher*, C—*charge vestibule*, D—*charging pushers*, E—*furnace chamber*, F—*transfer pusher*, G—*quench platform in vestibule*, H—*discharge position*, J—*discharge pusher*, K—*discharge track*, L—*pusher*, M—*washing machine*, N—*rinsing booth*, P—*unloading and loading track*, Q—*transfer trolley*



New work is mounted on special trays and fed into the charge vestibule on the conveyor shown

with consistent properties and has a very low, virtually negligible, sulphur content.

The Birlec furnace installation has been in operation for several months and only a few "shake-down" troubles of minor character were encountered initially. This is regarded as reflecting the thoroughness of the investigations that preceded the finalizing of the design. The consistently high standard of physical properties of the work treated and the reduced distortion of workpieces have amply fulfilled expectations. Currently, the throughput is of the order of 30 tons per week, mainly consisting of automobile transmission gears.

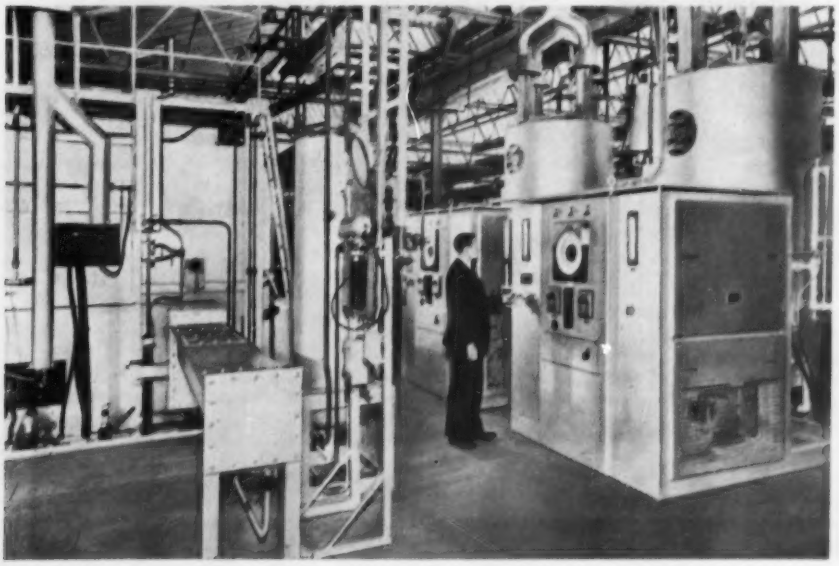
Furnace capacity

The furnace has a rated output of 600 lb of work per hour but this figure may be exceeded if only a medium depth of case is required. For a continuous working week of 168 hours, therefore, a throughput of 40–45 tons is possible. The length of the heating chamber is 31 ft and all operations, loading, carburizing, quenching, washing and unloading, are carried out within a floor space of 49 ft × 25 ft. Gears to be treated are loaded on to 18in × 18in grid type trays of 37/18 nickel-chrome heat-resistant alloy, each tray carrying up to 150 lb of work. Fixtures are provided for the support of certain types of gears and pinions to enable the trays to be used to the best advantage.

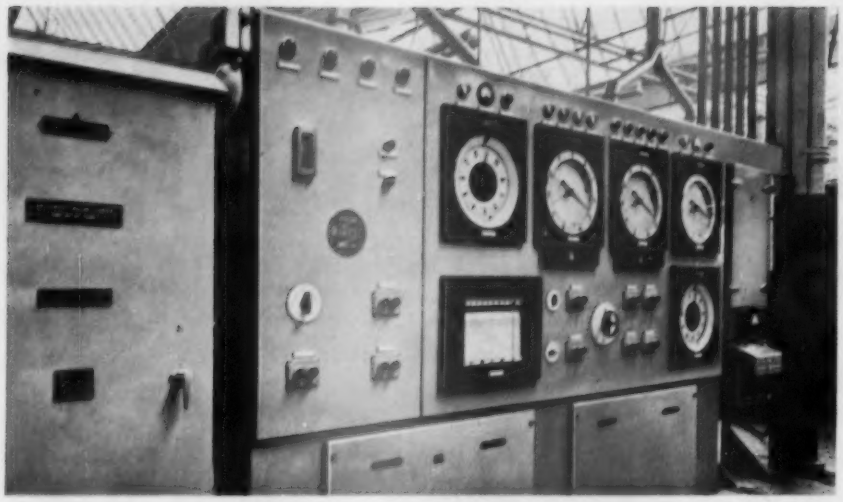
Heating and atmosphere

Heating is by radiant tubes fired by town's gas. The tubes are arranged transversely above and below the conveyor tracks, the upper tubes being fired from one side of the furnace and the lower tubes from the other side. This refers to the tubes in the preheating and the two soaking zones; U-tubes fired and exhausted from the same side of the furnace are employed for the final zone in order to accommodate the quenching and discharging equipment. Full furnace output is obtained with a gas consumption of approximately 4,200 ft³/hr.

Carburizing atmosphere is produced from propane in two Birlec endothermic atmosphere generators heated by town's gas. These together consume about 160 ft³/hr of propane for an output of 1,600 ft³/hr of atmosphere gas to feed the furnace chamber continuously and 1,000 ft³/hr in



Discharge end of the furnace showing gas-tight casing of pusher and lock chamber pressure regulating equipment. On the right are two of the three atmosphere generators



The instrument panel with the recording and controlling instruments which provide automatic temperature regulation for the various zones of the furnace. Sequencing control gear is arranged behind the panel on the left

a periodic on-off supply for purging the charge and discharge vestibules. Three fans, equipped with water-cooled bearings, are mounted in the roof of the furnace chamber to circulate the atmosphere and maintain even distribution of heat.

Mechanization

The work-handling system is highly mechanized and automatically controlled and the furnace can be run at full output by only two operators. This number applies only when the work is automatically quenched direct from the furnace to an oil bath. When work is extracted from the furnace for press quenching, an additional operator is required to handle the gears individually from the furnace to the presses. In both cases, the carrier trays are continuously circulated through the furnace, quench tank and washing booths, so that labour is confined to the unloading of finished work and the reloading of the trays.

All work is cleansed in a washing machine before loading. The furnace operators also handle this operation and the tempering operation subsequent to casehardening. All movements are effected by hydraulic rams energized from a centralized pump unit and controlled electrically through the sequencing circuit. To eliminate fire hazards arising from leaks in the hydraulic equipment, a non-inflammabe fluid is used.

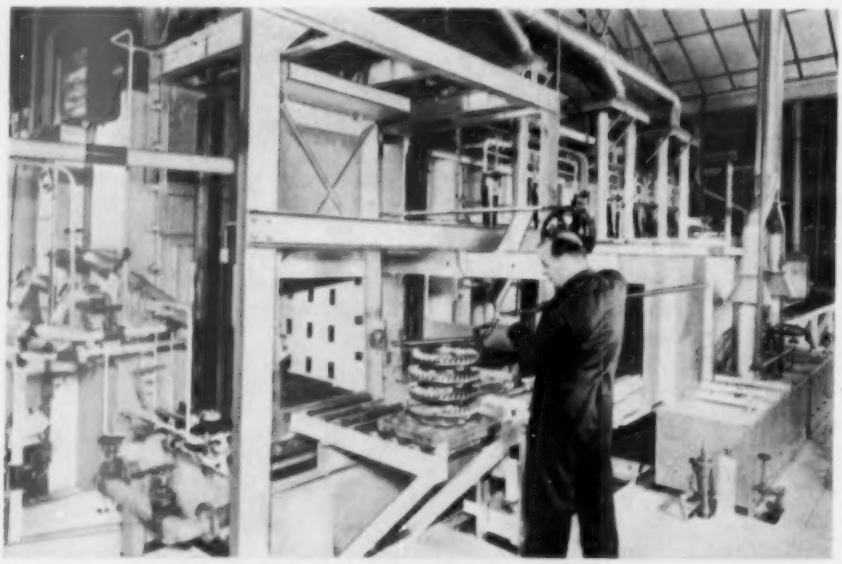
Charging

Normally, the furnace is charged after every third cycle, that is, when each of the three tracks has moved once. Trays loaded with work are moved by hand from the loading track to the transfer trolley. The door of the charge vestibule is opened and the loading carriage is extracted mechanically. The loaded trays are slid by hand from the trolley to the carriage which is then returned to the vestibule and the door is closed.

Furnace cycle

Each furnace track has an individual timer that rings a warning bell and gives a light signal at the pre-set push intervals. Thereafter, the depression of a push button starts the automatic sequence:

1. The inner door of the vestibule opens and the loaded tray aligned with a particular track is pushed from the vestibule into the furnace, moving the entire track one tray length forward. At the discharge end of the furnace, the leading



Crown wheels are here being transferred from the discharge vestibule to the quenching presses. Work not requiring to be press-quenched is direct-quenched in a tank below the vestibule

tray is lined up against a stop by an extractor mechanism.
2. The quench elevator rises, the inner discharge door opens, the tray is pushed on to the quench platform in the vestibule, and the inner door is closed again.
3. The quench elevator descends, immersing the tray of work in a rapidly moving vertical stream of oil for a preset period.
4. The tray of work is moved sideways in the quench tank and is then elevated to the discharge position.
5. From this position it is pushed on the discharge track to the unloading track.
6. On the unloading track it is pushed through the washing machine and the rinsing booth to the unloading position.
7. Unloaded trays continue along the track for reloading.

Press quenching

When work requiring to be press quenched is ready for discharge, a switch at the discharge end of the furnace is operated. This halts the sequence when the tray of work is in the discharge vestibule. A signal is given automatically and the outer door can then be raised to enable the work to be extracted. The tray is returned to the vestibule and the closing of the outer door re-starts the automatic cycle.

Purging

On each occasion that the outer door of a vestibule is opened the atmosphere within burns away. When the door is again closed the generator providing the atmosphere gas for purging is automatically brought into operation and gas is fed into the vestibule for a predetermined period to sweep out the air and burnt gas and to restore the atmosphere.

Metallurgical control

In the usual manner, the depth of the case formed on the work can be varied by regulation of furnace temperature and of soaking time. The carbon content of the case is determined independently by the composition of the atmosphere gas. Generally, the correct carburizing temperature for given conditions is higher than the optimum temperature for quenching.

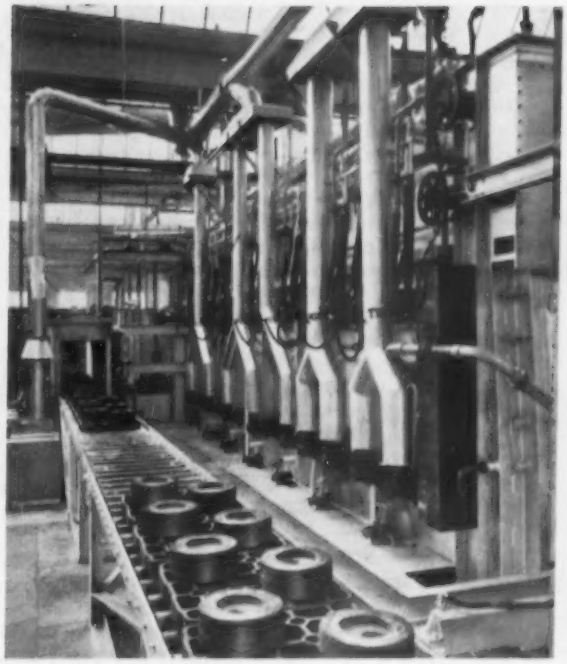
The furnace chamber is divided into four successive zones, each subjected to an individual automatic temperature control. In the first zone the temperature of the work is raised to the specified value and in the second and third zones that temperature is maintained for a period determined by the rate at which the trays are moved along the tracks. It is in these two zones that the gas-circulating fans are located. In the fourth zone the temperature of the work is, generally, reduced to a second specified level to provide correct condition for quenching.

To assess the carburizing potential of the atmosphere gas a recording instrument is provided for the measurement of its dew point. This can be arranged to operate either on the generator gas or on the furnace atmosphere, which comprises the generator gas enriched with propane. To produce a case of approximately 0·8 per cent carbon content, a propane addition of about 1 per cent of the atmosphere gas flow is needed. This corresponds to a depression of the gas dew point from 20–40 deg C as generated to 10–15 deg C in the furnace.

Case depths ranging from 0·03in to 0·06in are obtained by variation of the cycle time. A cycle time of 27 minutes is, for practical purposes, considered as the minimum. At that timing a tray of work requires about 9 hours to traverse the furnace and under those conditions an output up to 800 lb/hr is obtainable with work requiring a case depth of 0·038in. Individual timing of the furnace tracks, as already noted, enables work requiring different case depths to be treated simultaneously.

Atmosphere generators

Three Birlec generators are installed; two in operation and one held in readiness as a stand-by. Apart from covering an emergency, this arrangement enables the periodic regeneration of the catalyst to be undertaken without interrupting the operation of the furnace. Regeneration is only necessary after some weeks continuous operation but involves lowering the generator temperature to approximately 700 deg C and blowing air through the catalyst for about 12 hours. The operation is repeatable and the life of the catalyst usually exceeds 6 months.



Roller track for unloading work after leaving the washing booth and for return of the grid type work trays. On the side of the furnace will be seen the burner ends of the upper radiant tubes and the exhaust ends of the lower tubes

Propane is supplied by Shell-Mex and B.P. Ltd. in special pressurized road tankers carrying 4 tons of the liquefied gas and is transferred, still under pressure, to an open-air bulk storage station. Storage vessels are made to a rigid specification and are equipped with appropriate safety devices.

The maximum vapour pressure of propane is 270 lb/in² abs. at a temperature of 45 deg C and small containers must be designed to withstand an internal pressure of that order. It is highly improbable that the contents of a large container would ever reach a temperature of 45 deg C under British climatic conditions. Accordingly, large storage vessels may be built for a maximum pressure of 210 lb/in² abs. The cost of propane used to produce a carburizing atmosphere is strictly competitive with that of town's gas suitably enriched for the same purpose.

Conclusion

This new continuous furnace eliminates the costly and laborious features of pack carburizing and avoids the limitations of gas carburizing by batch methods. It brings the carburizing process into line with contemporary production methods and is admirably suited to the flow line requirements of automobile plants. Manual handling is reduced to a minimum, resulting in economy in labour and floor space, and fuel consumption is reduced. The mechanical system uses only simple individual components and, together with the sequence controls, gives no trouble in operation.

Aluminium Alloy Castings

Notes on Heat-treatment

By far the greater proportion of castings are used in the as-cast condition but there are a number of special applications for which higher mechanical properties are required. A very considerable increase in strength and hardness, compared with the as-cast condition, is obtained by heat-treating castings of suitable alloys, and the purpose of these notes is to set out briefly the conditions applicable to treatment of the various alloys, the scope and limitations of the process and the precautions to be observed. With the exception of the sections describing solution treatment and quenching which do not apply to pressure diecastings the practice described applies to all three forms of castings, that is, sand, gravity and pressure diecastings. Heat-treatment for the improvement of mechanical properties usually consists of three main operations :—solution treatment, quenching and precipitation treatment.

Solution treatment

In this first stage the castings are subjected to prolonged heating at a temperature only a little below that at which the alloy begins to melt. By this means, it is possible to effect the solid solution of certain of the alloying constituents which were originally in solution when the alloy was in the liquid state but were precipitated as the metal solidified and cooled in the mould. When the maximum solution obtainable at the heat-treatment temperature is achieved, the castings are rapidly cooled to room temperature, usually by quenching in water. This operation is referred to later.

As the temperature at which the solution treatment is conducted is very near that at which the alloy begins to melt, it is obviously important that the temperature of the castings should be very closely controlled throughout the treatment. Furnaces for heat-treatment are designed to ensure uniformity of temperature throughout a charge of castings, and the temperature at two or more points is automatically controlled and recorded throughout the treatment. It follows that the process is not one which can be carried out with equipment designed for any other purpose.

Two types of furnaces are obtainable for the heat-treatment of castings (*a*) the forced air circulation furnace and (*b*) the salt bath. Although initially more expensive to purchase and install, the forced air furnace has many advantages over the salt bath and is far more widely used for castings than the salt bath which is more suitable for the heat-treatment of wrought forms of aluminium alloys.

As its name implies, the forced air circulation furnace is one in which the castings are heated by a current of hot air maintained in rapid re-circulation by a large fan within the furnace. Heating is most commonly by electrical resistors arranged around the wall of the furnace, but furnaces fired by gas or other fuels are obtainable. The air furnace is particularly suitable for the heat-treatment of castings treated in batches, usually contained in a charging basket. The low heat capacity of the forced air circulation furnace compared with that of the salt bath is on the whole an advantage since it not only avoids the thermal shock experienced by castings plunged into a hot bath, but it ensures that the ultimate heat-treatment temperature is approached slowly.

The salt bath consists essentially of a steel tank containing sodium nitrate or a mixture of sodium nitrate with sodium nitrite or potassium nitrate heated either internally by immersion heaters or externally by gas or oil. At the heat-treatment temperature the salt is, of course, molten, and if the bath is small, uniformity of temperature is maintained without the need for stirring. Temperature control and recording should be automatic as with the air furnace.

The operation of a salt bath is simplified if the salt mixture is kept molten between treatments. To some extent this makes the salt bath type of furnace uneconomical if used only intermittently. Probably the greatest disadvantage of the salt bath compared with the air furnace is that in the transference of batches of castings from the bath to the quenching tank very high drag-out losses of salt occur, the salt being mechanically trapped in the cavities and hollow sections of the castings. Furthermore, the quenching of castings holding considerable amounts of salt may be dangerous. When castings are quenched singly—this is sometimes desirable with large castings—the same objections do not apply since most of the molten salt can be removed from the casting before quenching. The salt bath has the advantage that, when castings are removed one at a time, the temperature of the bath is not affected whereas the temperature in a forced air furnace will fall slightly if the furnace is opened to remove castings one by one. Treatment in this manner only applies, of course, to large castings.

Heat-treatment temperatures

The solution treatment temperatures for the various alloys must be rigidly observed. Should the maximum permissable temperature be exceeded, one or more of the constituents of the alloy may melt, and the casting will collapse or crack or will be found to be covered on the surface with small "pimples" or excrescences according to the shape of the casting and the degree of over-heating. If over-heating occurs, it cannot be rectified and the castings must be scrapped. If, by accident, the treatment should be carried out at a temperature below the minimum specified, the required mechanical properties will not be achieved but no irrevocable damage will have been done, and the castings may be heat-treated again at the correct temperature without harmful effect.

Heat-treatment times

The length of time necessary to effect maximum solution must generally be determined by trial—it depends on the thickness of the casting and on the grain size and composition of the alloy. Broadly speaking, the time required increases with the coarseness of the structure; thicker parts require longer time than thinner parts and sand castings longer than chill castings. Normally, test bars are heat-treated with the castings to confirm the effectiveness of the treatment. If the castings are thicker than the test pieces, as may sometimes happen, they will require a longer treatment. This means that the minimum time required to obtain satisfactory solution in the test pieces will be exceeded.

The necessary solution of the alloying constituent obtained at the solution treatment temperature must be retained by cooling to room temperature as quickly as possible—slow cooling would allow an undesirable form of precipitation and the beneficial effect of the treatment would be lost. The interval between the moment of opening the furnace to remove the castings and complete immersion in the quenching liquid must be as short as possible. In general this interval should not exceed 30 seconds but the maximum permissible time will depend upon the mass and volume of the total charge and of the individual castings—the

thinner the casting, the more rapidly will its temperature fall during transference. In order to minimise the quenching interval, quenching tanks are placed as near to the furnace as is practicable and the raising and lowering of the furnace charge is usually effected by a high speed electric hoist. The usual quenching medium is water, but in special circumstances oil or air is sometimes used.

When a casting varies very considerably in thickness in its various parts, or is of complex shape, it is difficult to avoid some degree of distortion on quenching, since the speed of cooling and contraction differs from one section to another. In order to prevent or at least minimise this distortion, and avoid the formation of internal stresses which might later cause distortion, it is advisable, wherever possible, to quench in hot or boiling water. As cooling is slower when quenching in hot water than in cold, the retention of the essential constituent in solid solution is not quite so complete and consequently the strength and hardness of the casting may be lower. The choice of temperature of the quenching bath and the medium may sometimes depend on the relative importance of the mechanical properties of the casting on the one hand, and the need for preventing distortion or the formation of internal stresses on the other; in many large or complicated castings it is necessary to sacrifice some mechanical strength for maximum dimensional stability and in certain cases slower quenching using oil or even air may be necessary.

Precipitation treatment

Some alloys are used in the solution treated condition (usually where maximum ductility or perhaps shock resistance is required) but more often greater strength and hardness are desired and the solution treatment is followed by a low temperature precipitation treatment. Unlike many of the wrought aluminium alloys, the solution treated cast alloys (except "Y" alloy) do not greatly increase in strength and hardness by ageing at room temperature.

Precipitation treatment consists simply of heating the castings at a temperature generally between 150 and 200 deg C. for a number of hours during which time precipitation occurs, on a sub-microscopic scale, of the constituent dissolved during the solution treatment. The appropriate times and temperatures for precipitation treatment times may be determined quite simply by trial and error. This may be done by testing samples withdrawn from treatment at intervals. Generally, strength and hardness increase fairly rapidly during the first few hours of treatment and then more slowly. Beyond a certain time, continuation of treatment results in no further increase in mechanical properties but, if extended very considerably, will cause the strength and hardness to fall. Should castings be accidently over-aged either through heating at too high a temperature or for too long a time, the required properties can be obtained by a second solution treatment and quench followed by precipitation treatment at the correct temperature and time. Interruption of precipitation treatment has no harmful effect on the castings; the hardening effect of separate treatments is additive. The speed of cooling following the precipitation treatment is not important.

Because the working temperatures are lower and less critical, equipment for precipitation treatment can be simpler in construction and control than that required for solution treatment. Almost any oven which can be fitted with a simple thermostatic control and temperature chart recorder is suitable for the precipitation treatment, provided the temperature differences at various positions are not greater than two or three degrees. For larger ovens an air circulating fan will probably be necessary and temperatures should be recorded at two positions. If it is not in continuous use for solution treatment, the forced air circulation high temperature furnace is, of course, ideally suitable for precipitation heat-treatment.

There is no reason to believe that the interval between quenching and precipitation treatment has any significant effect on the final properties of those alloys which do not age-harden at room temperature. Where marked hardening at room temperature does follow quenching, there is some evidence that with these alloys an interval of a day improves the elongation, whilst precipitation treatment immediately following quenching gives maximum strength and hardness but lower elongation.

Precipitation without solution treatment

The cooling of a casting after pouring constitutes a mild form of quenching and some constituent responsive to heat-treatment may be retained in solid solution. When this occurs, a small increase in strength and hardness may be produced by precipitation treating the castings. If a heat-treatable alloy is gravity diecast, especially if it is of fairly thin section, a high proportion of the hardening constituent may be retained in solid solution. If the casting is quenched in water immediately after being removed from the die, the proportion will be even higher. Precipitation treatment of die-castings produced in this way results in greatly improved properties.

The form of heat-treatment known as annealing is not one which is often applied to aluminium alloy castings. If it should be necessary, castings which have been heat-treated can be softened again by heating at about 350 deg C. followed by slow cooling in the furnace; the longer the time the greater the degree of softening. Heating produces no appreciable permanent softening in non-heat-treatable castings but may reduce internal stresses—the stabilizing treatment described below is sometimes known as stress relief annealing.

Heat-treatment of pressure diecastings

Pressure diecastings like gravity diecastings have commonly greater mechanical strength than castings produced in sand moulds, and it might be expected that this superiority in strength could be further increased by heat-treatment as it can with gravity diecastings. Unfortunately, however, the solution heat-treatment of pressure diecastings introduces a problem which does not arise in the case of sand castings or gravity diecastings, and which renders the full heat-treatment of almost all commercially produced pressure diecastings impossible.

Examination of a pressure diecasting by fracturing or by radiography may show that it is no less sound than a sand or gravity diecasting which can be satisfactorily solution heat-treated, yet, if the pressure diecasting is similarly heat-treated, it will probably be found to be distorted and covered with "pimples".

Almost all pressure diecastings contain bubbles either of air or of gas from die lubricants: if very small and well dispersed, they do not affect the strength of the casting. These bubbles are entrapped by the rapidly moving and turbulent stream of metal injected into the die, and the gas is retained under the diecasting pressure as the casting solidifies. (This gas must not be confused with the gas which may be dissolved by the metal during melting and may subsequently be released as the metal solidifies.) When the pressure diecasting is heated to the solution heat-treatment temperature, the pressure in the bubbles increases and the strength of the metal falls. The casting is unable to prevent the expansion of the gas bubbles, and as a result the castings become distorted and "pimples" appear on the surface.

These notes are based on a recently issued Alar data sheet. Copies of the data sheet may be obtained, free of charge, from Alar Limited, 3 Albemarle Street, London, W.1.

GEAR MACHINING

Recent American Automatic Developments

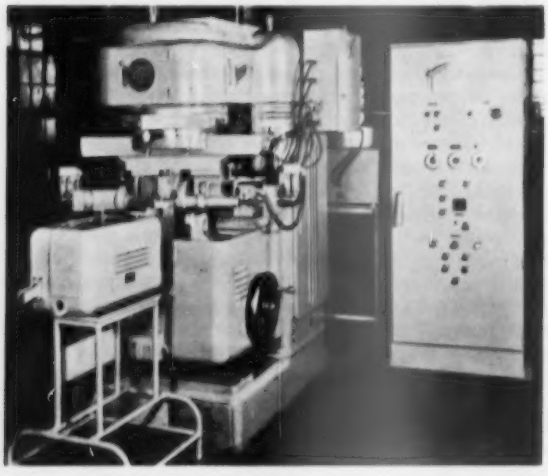
THESE notes deal with two American machines which incorporate automatic inspection systems in the machine cycle. The first, which is illustrated in Fig. 1, is a Michigan "Gear-O-Mation" equipped underpass gear shaver, built by Michigan Tool Company, Detroit, Michigan, U.S.A. Essentially, it comprises an underpass gear shaver with vibrating hopper feed, automatic loading, a three-way probe-type gear classifier and a control panel. This machine produces 260 automobile pinions per hour.

The 18-tooth pinion has a face width of 1¼in, an outside diameter of 1·1419in and a bore diameter of 0·6876–0·6881in. From 0·004in to 0·006in stock is removed in the shaving operation. The work is held on stub arbors mounted in the headstock and tailstock of the machine. These arbors have an outside diameter of 0·6873–0·6875in, which makes them a light press fit in the bore of the gear. When the gear is loaded in to the machine, the headstock centre, which is powered by a 6in diameter pneumatic cylinder, is advanced into the bore of the gear until the stub arbor meets a stop. The tailstock centre, actuated by a 4in diameter pneumatic cylinder, then advances until its stub arbor contacts the headstock stub arbor with a specified pressure. Almost invariably the sub arbors are freely retracted from the work after the shaving is completed.

In addition to controlling the operation of the machine, the control panel counts correct size gears and keeps account of oversize or undersize gears both as a percentage of production and on a total count basis. A feedback system, actuated by the gear classifier through the control panel, automatically corrects the centre distance when the gears come under or oversize. If the faulty condition persists, the machine shuts down automatically for the necessary corrections.

After the gears are shaved, they pass through a chute to the three-way gear selector, with correct size gears passing straight through. Undersize or oversize gears are diverted, each one being counted by the control panel. This type of quality control through the feedback system, checks every shaved gear for size and ensures that every accepted gear will be within the specified tolerance. It also ensures that faulty work is kept to a minimum.

Fig. 1. Michigan gear shaver with automatic loading and automatic inspection devices



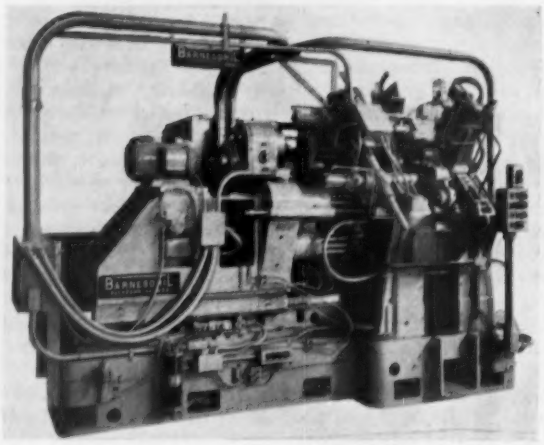


Fig. 2. Eight-station BarnesdriL machine with a fully automatic cycle

The second machine, illustrated in Fig. 2, is one of four recently supplied by Barnes Drill Company to the Warren plant of the Ford Motor Company. It has been developed for drilling, reaming, chamfering and tapping holes in rear axles ring gears. Essentially, it is an eight-station drum type machine, with automatic loading and unloading devices including electrical, hydraulic and interlocking equipment for a complete automatic cycle.

Gear blanks for the machine are supplied from a battery of lathes. A conveyor system from the lathes drops the gear blanks into the loading pocket, whence, with a completely interlocked cycle, a loading arm picks up the blank and deposits it in the loading position. There it is automatically clamped.

A 50-spindle auxiliary head is mounted on a BarnesdriL saddle type unit that is complete with slide, and with hydraulic equipment to give rapid approach, feed and rapid return. The head consists of 40 drilling spindles and 10 individual lead screw tapping spindles. The drilling section and the tapping section have individual motor drives.

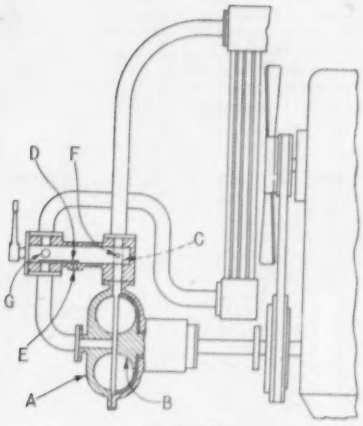
Drilling is carried out at stations Nos. 2 and 3. Station No. 4 is arranged for chip blow-out, gauging and probing. If inadequate depth of hole or a broken tool is detected by the probing unit at station No. 4, the machine is automatically stopped and a red signal light is illuminated. The machine is restarted when the faulty part has been removed through the reject chute and the necessary tool corrections have been made. Chamfering is carried out at station No. 5, reaming at No. 6, and tapping at stations 7 and 8. When the part is returned to station No. 1, it is automatically unclamped, the unloading arm picks it up and deposits it in the discharge pocket for return to the conveyor line for transfer to the next operation. At 80 per cent efficiency, production for the battery of four machines exceeds 800 components per hour. Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, are the British agents for the machines described in these notes.

CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Fluid-friction engine brake

To supplement the normal braking effect obtained from an engine when, with the fuel supply cut off, it is driven by the vehicle, a liquid brake coupled to the engine shaft is provided. Arranged at the front end of the engine, the brake comprises a stationary casing A having a bladed toroidal chamber in which rotates a complementary bladed impeller B, driven from the engine. The blading is designed for the maximum dissipation of energy and also to pump fluid through an external circuit which includes the normal radiator.



No. 742293

The brake draws water from the bottom tank and returns it to the header tank.

Control is effected by cocks in the inlet and delivery conduits. These cocks are on a common stem and may be actuated by an independent hand control, or in conjunction with either the vehicle brake pedal or accelerator. In the position shown in the illustration the pump delivery port is freely open through passage C in the delivery cock while the inlet is open to atmosphere by way of a longitudinal groove D in the inlet cock and a port E. The pumping action empties the casing A and thereafter there is little expenditure of energy.

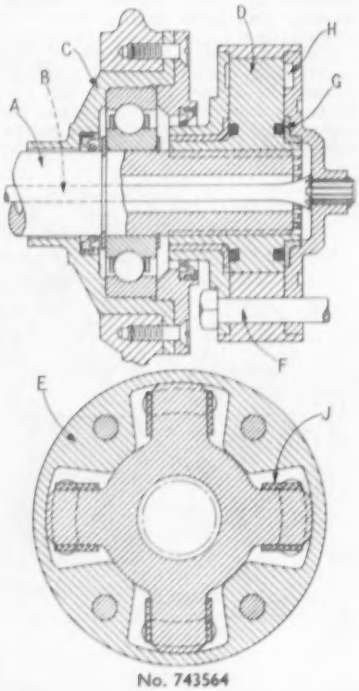
When the cocks are turned through an angle of 90 deg., a restricted passage F is aligned with the delivery port and a full-bore passage G is opened to the inlet. The casing A is immediately filled and energy is dissipated in churning and heating the fluid. Passage F permits a sufficient flow back to the radiator to keep the temperature rise in the brake within a convenient limit and, particularly, below boiling point. The casing may be formed externally with cooling fins. *Patent No.* 742293. *Leyland Motors Ltd.*

Torsionally resilient transmission coupling

When a diesel or other high-compression engine is idling there are considerable fluctuations in the angular velocity of the crankshaft and these fluctuations may cause an objectionable chatter in the gearbox. In this coupling, lost motion is arranged between driving and driven elements and under conditions of virtually no load the drive is taken through a light torsion rod and relative displacement is hydraulically damped.

Drive shaft A, extending from the engine clutch to the gearbox, is hollow and accommodates a light torsion rod B which has a splined engagement with the shaft at its forward end and at the rear projects beyond the end of the shaft. The shaft is supported in a ball bearing in a fixed housing C and carries on its splined end the vaned driving member D of the coupling. Enshrouding member D is the driven member E with complementary recesses of greater radial width than the vanes of the driver. Enclosure is completed by front and rear covers suitably bushed for angular movements on spigots on member D, the rear cover having a splined boss engaged on the end of the torsion rod. The covers are secured by bolts F by which the driven member E is attached to the input shaft of the gearbox.

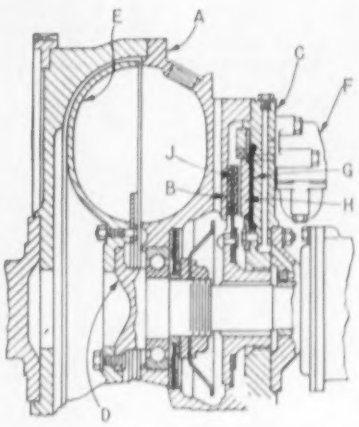
The driving member makes a running fit with the driven member and the covers, the recesses in the driven member being filled with oil and sealed by rings G. Ports H in the covers permit relative movement and transfer of oil across the vanes under torsional oscillation to be damped merely by the viscosity of the oil. When a gear is engaged, however, and the engine takes up the load, the torsion bar yields sufficiently for the vanes to close the ports and thereafter transfer of oil is by way of the running clearances. Thus a solid drive is taken up smoothly. To avoid metallic contact resilient pads J may be fitted to the vanes, but these are not essential. *Patent No.* 743564. *Guy Motors Ltd.*



No. 743564

Hydraulic coupling drive

Although the inclusion of a hydraulic coupling in the transmission system is of particular advantage in an urban bus which must frequently stop and restart, its continuous use will increase the rate of fuel consumption as a result of slip. The purpose of this invention is to reduce the loss of energy from this source by automatically locking the coupling by means of a pneumatically operated friction clutch when a certain rotational speed is reached and unlocking it at a suitably lower speed of rotation.



No. 740363

On the impeller part A of the hydraulic coupling is formed an annular friction face B surrounded by a circular flange. To this flange is secured a radially drilled annulus C ; the three elements forming a housing for the friction clutch. The driven shaft D runs in a ball bearing mounted in impeller casing A and carries the runner E. On the external face of annulus C is mounted a plurality of spring-loaded air valves F, which control the admission of compressed air to a diaphragm type servomotor G, which displaces presser plate H to grip the friction clutch disc J splined to the driven shaft D.

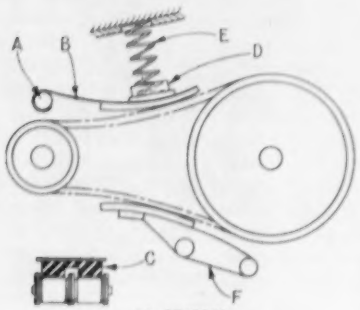
When idling, the air valve is closed by air pressure on the larger diameter of the poppet and the loading spring, the friction clutch is disengaged, and the hydraulic coupling is operative. As the vehicle moves off and gathers speed, engine speed is increased to a predetermined value at which centrifugal force on the valve poppet exceeds the restraining forces and the valve is opened to lock the drive. When the vehicle is slowed down preparatory to stopping, centrifugal force eventually is overcome by the combination of the loading spring and air pressure on the smaller diameter of the poppet, the drive is unlocked and air behind the diaphragm is vented to atmosphere.

The arrangement requires a rotary seal on the rear hub of the coupling casing to permit the transfer of compressed air from a stationary reservoir to the drillings in annulus C. *Patent No.* 740363. *Leyland Motors Ltd.*

Chain-tensioning devices

Chain tensioners comprising steel strips pressed against the edges of the side links of the chain are responsible for an appreciable frictional loss of power, occasion relatively heavy wear of the strip and links, and are likely to be noisy in operation. All these disadvantages are obviated by the proposed device in which a strip of rubber, or rubber-like material engages only the rollers of the chain. The rubber should be resistant to oil and to temperatures of 100 deg C, or more, and have a hardness not exceeding 100 Shore.

The diagram shows the tensioner applied to the upper, slack run of a two-row chain. A steel strip A, pivotally supported on a stud B, has vulcanized or otherwise bonded to its face a rubber strip C which is suitably profiled to contact only the chain rollers. On the back of strip A, at a point approximately central of the rubber strip, is a shoe D and the tensioner is loaded by a helical spring E constrained between this shoe and a fixed abutment. Instead of the helical spring, any other type of spring or a hydraulic device may be used. Between the minimum and the maximum sag of the chain, the loading should not vary more than 10 per cent.



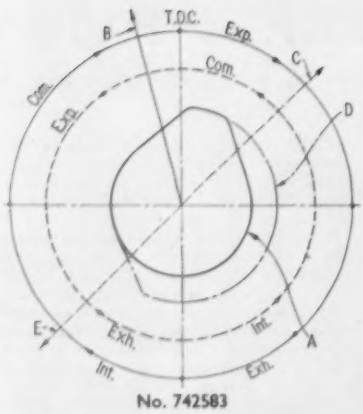
No. 742092

On the lower, tight run of the chain is an additional tensioner, comprising a similar steel-backed rubber strip loaded in this instance by a hairpin spring F. *Patent No.* 742092. *Daimler-Benz A.G (Germany).*

Preventing reversal of fuel-injection engines

Under certain conditions fuel-injection engines, particularly compression-ignition engines, will start and run in reverse rotation, using the exhaust system for air intake and the inlet system for exhaust. Where a pneumatic type governor is fitted such reverse running can have serious results as pressure in the air manifold will assist the governor spring to hold the injection pump rack in the "full delivery" position and an uncontrolled acceleration can occur. The immediate reaction of the operator is to close the throttle and pull the "stop" control. This merely serves to raise the pressure in the manifold and consequently to render the stop control very difficult to operate. Correct procedure would be to open fully the throttle to reduce the exhaust pressure in the manifold, when the stop control can be operated easily.

The invention eliminates the possibility of reverse running after a reverse start by means of a modified fuel-injection pump cam. With this, in the event of initial reversal, fuel is injected during the exhaust stroke and is blown out of the cylinder



No. 742583

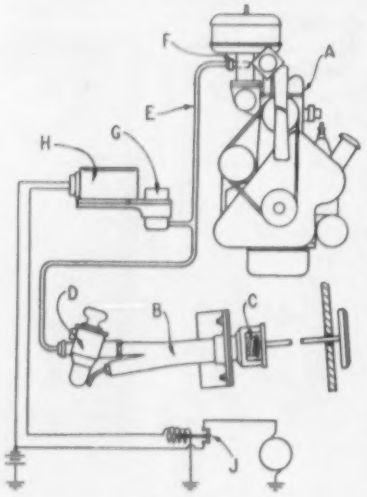
through the inlet valve.

In the timing diagram appended, the outer circle in continuous line shows, clockwise, the normal operating cycle with a conventional cam A. The commencement of injection is at B. Under conditions of reverse rotation the cycle is shown, anti-clockwise, on the inner, broken line circle, and injection would commence at C in the compression stroke. With the cam modified on one flank, as indicated by the chain-dot profile D, however, injection would start at E in the exhaust stroke. *Patent No.* 742583. *Ford Motor Co. Ltd.*

Lightweight diesel engine

A compression-ignition engine of a weight suitable for an automobile, station waggon, or delivery van needs to operate on a compression ratio lower than the 16 : 1, or higher, usually regarded as essential in order to ensure starting at temperatures 10 deg to 15 deg below freezing point. For engines of from 2·5in to 3·0in bore a compression ratio of from 10 : 1 to 14 : 1 is suggested. According to the invention, the starting difficulty with such relatively low compression ratios is overcome by special equipment supplementing the usual starting motor or starting crank.

For this purpose the use of heater plugs is mentioned, but the preferred method is to introduce a relatively volatile fuel into the intake manifold. Once the engine has been started and is running on normal diesel fuel, the maximum combustion

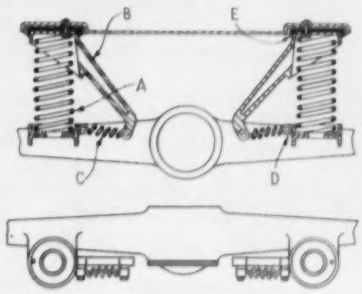


No. 742719

pressure will be less than that of a conventional spark-ignition engine of the same bore. Even with a sticking injector needle the pressure will not exceed that of the spark-ignition engine.

The engine A is of the swirl-chamber type associated with the name of the inventor and described in an earlier Patent No. 531075. A container for the volatile starting fuel (not shown) is connected to the inlet valve of a pump B, the plunger of which projects through the body front bulkhead and is operable by a handle. The plunger incorporates a screw-down shut-off valve C which must be released by rotation of the plunger before the pump can be operated. Fuel is delivered past a non-return valve and a filter D and passes by way of pipe E to the special injector F in the air manifold.

A branch from pipe E leads to a pressure-responsive unit G by which a switch H is closed when sufficient pressure is generated by pump B. This switch completes the circuit through the usual storage battery for a starting relay J and energizes the starting motor. The starting fuel may be a mixture by volume of 10 per cent ether and 90 per cent fuel oil or of ether and a cylinder head lubricant. *Patent No.* 742719. *A. F. Saunders.*

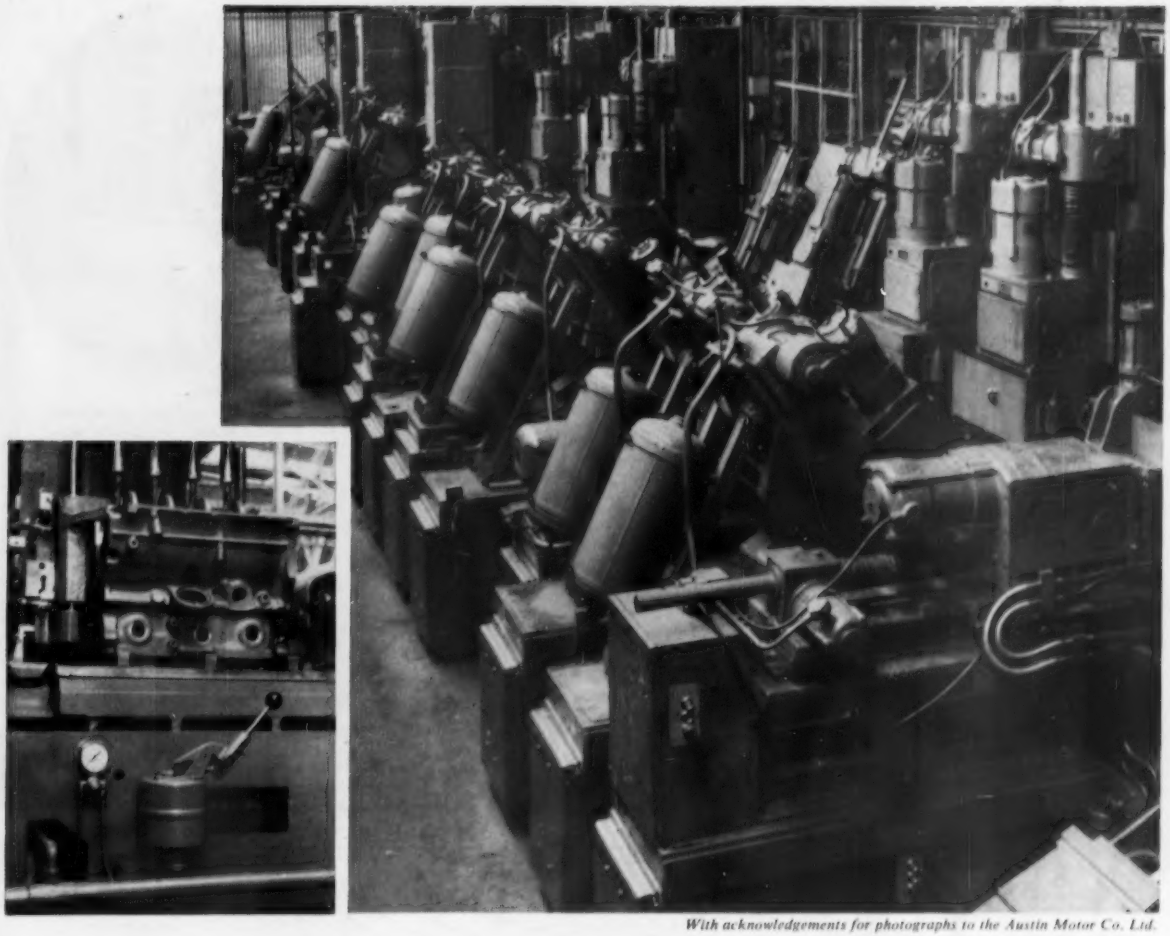


No. 740002

Variable-rate rear suspension

An earlier specification, No. 674224, described a variable-rate suspension in which a main helical spring in compression was supplemented by one or more laterally disposed helical springs operating in tension. While in new constructions adequate provision could be made, in the case of replacement or adaptation to existing vehicles the auxiliary springs could subject the structure to stresses for which it was not originally designed. Accordingly it is arranged for each suspension assembly to be built as a self-contained, interchangeable unit that can be specified in respect of its characteristics and checked ready for supply and mounting on the vehicle. The method is applied to systems having two auxiliary springs disposed longitudinally on the vehicle as well as to the system illustrated, in which a single tension spring is arranged transversely on the vehicle.

Main compression spring A is mounted between the axle casing and a frame bracket in the usual manner. Interposed between the frame bracket and the spring is a carrier B having a laterally depending arm to which is attached the auxiliary spring C. The other end of spring C is pivotally secured to a carrier plate D clamped between spring A and the axle casing. A rubber packing E is fitted above carrier B to prevent the transmission of vibration to the body structure and dowels or bolts may be fitted to maintain the radial location of the carriers. *Patent No.* 740002. *Société des Brevets J.A. Gregoire (France).*



With acknowledgements for photographs to the Austin Motor Co. Ltd.

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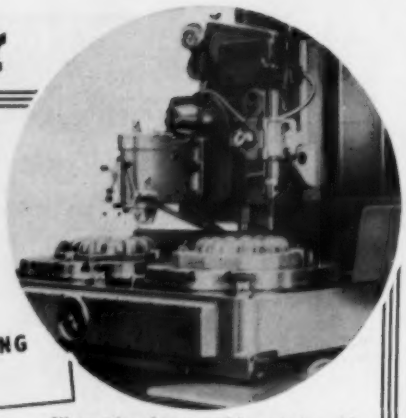

Illustration shows machine copying with vertical attachment fitted, and using the two rotary tables.

Arranged with two angle plates for simultaneous reproduction of two components

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CAPACITY	
Table, 2 Rotary Tables	27½in. dia.
Longitudinal Table Traverse (automatic)	39½in
Transverse movement of slide	15½in.
Vertical travel of spindle head	31½in.
Spindle Speeds (8)	70 to 800 or 335 to 3,600 r.p.m.
Feeds (8)	
Longitudinal Table Feed (per min.)	11in. to 8in.
Spindle Vertical Feed (per min.)	11in. to 5in
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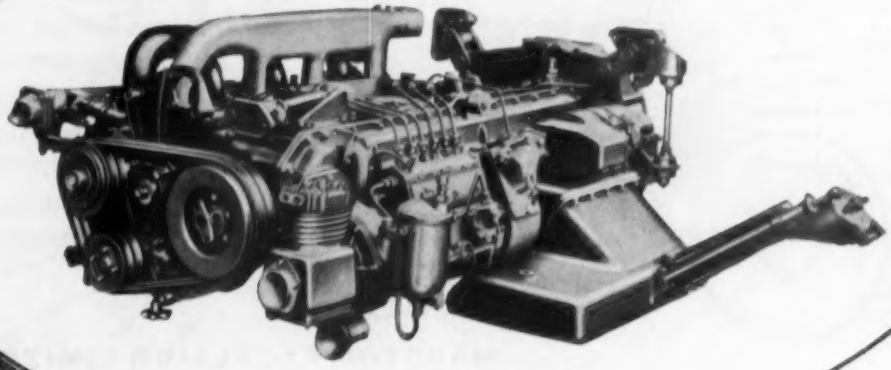

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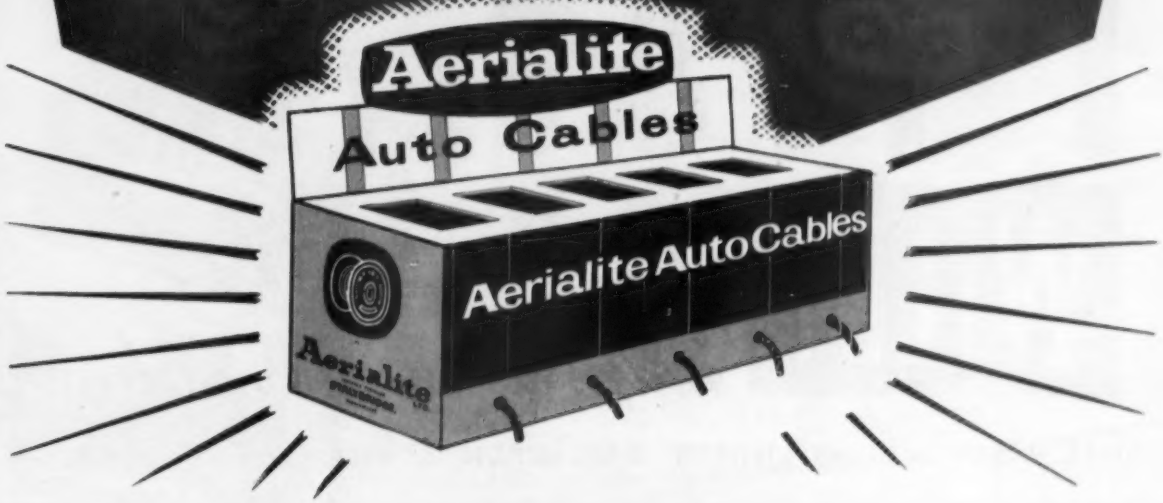

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14/012.	Single Auto	Cat. 287	100 ft. Super	...	1	10	0
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14/012.	Single Auto	Cat. 287	100 ft. Super	...	1	10	0
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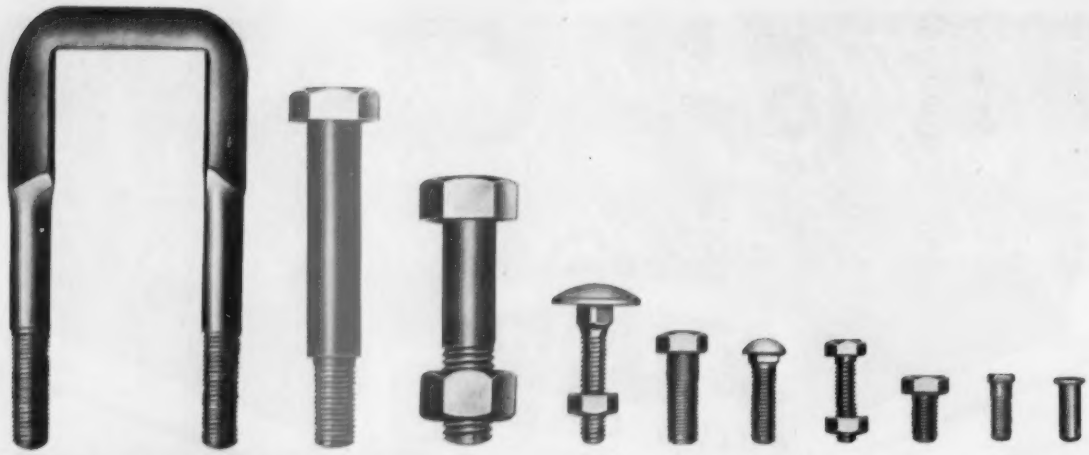

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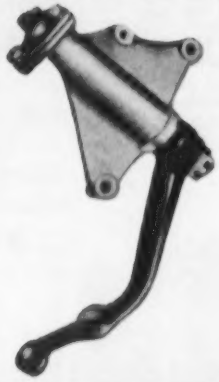

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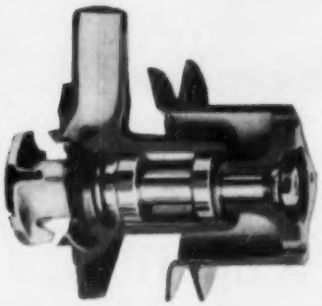

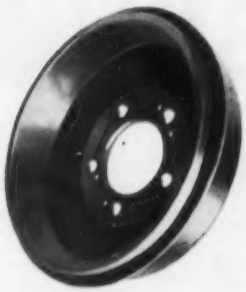

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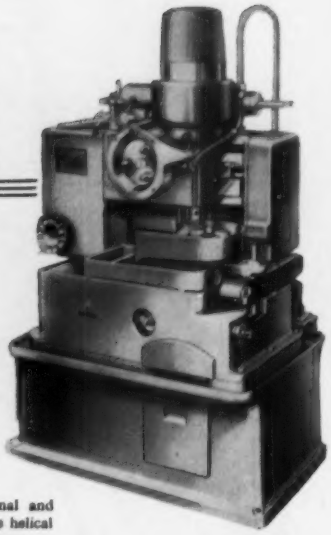

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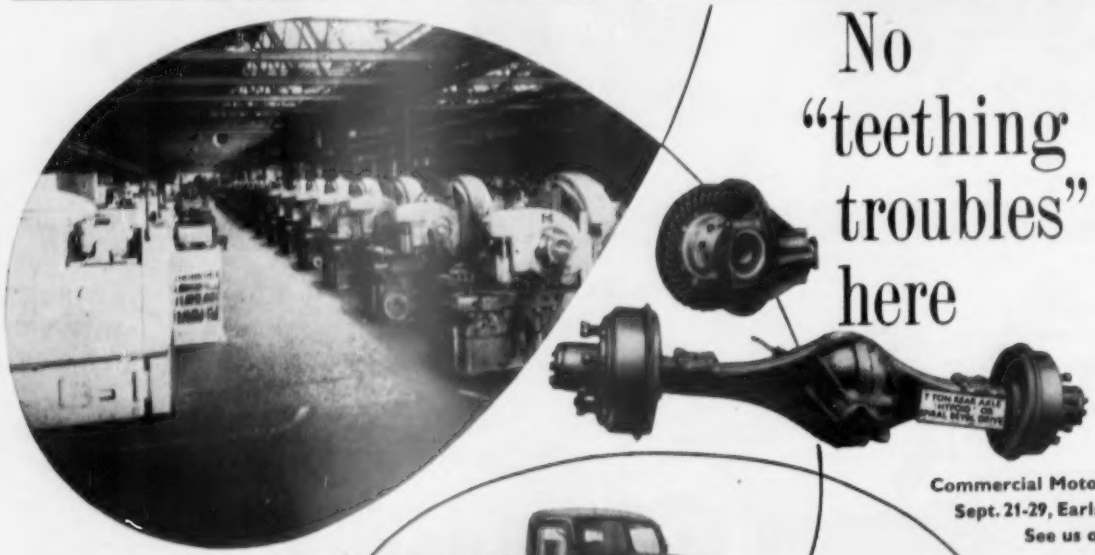

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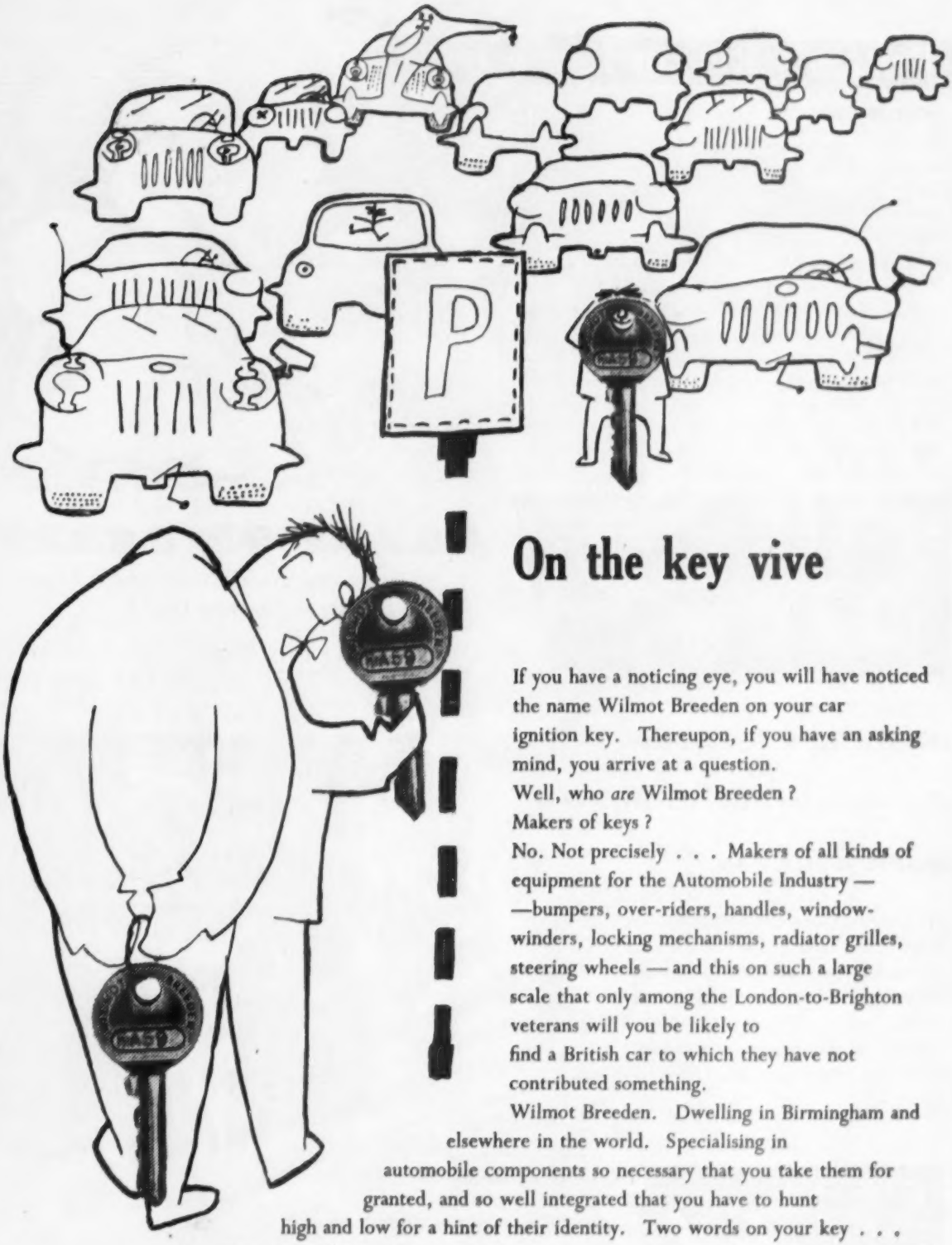

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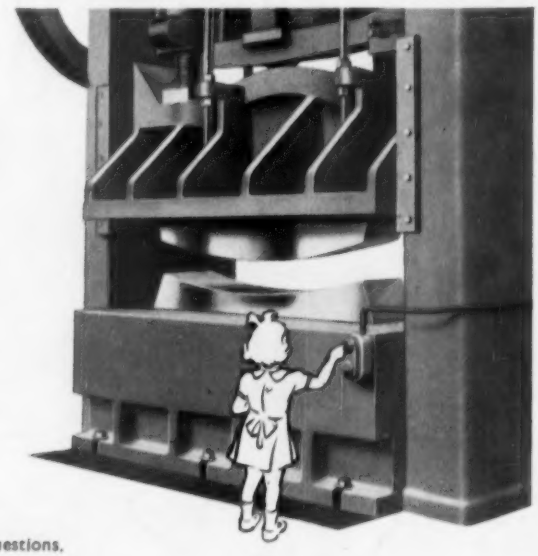

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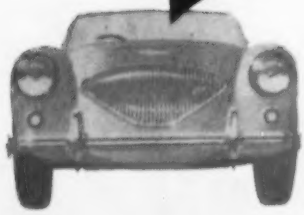

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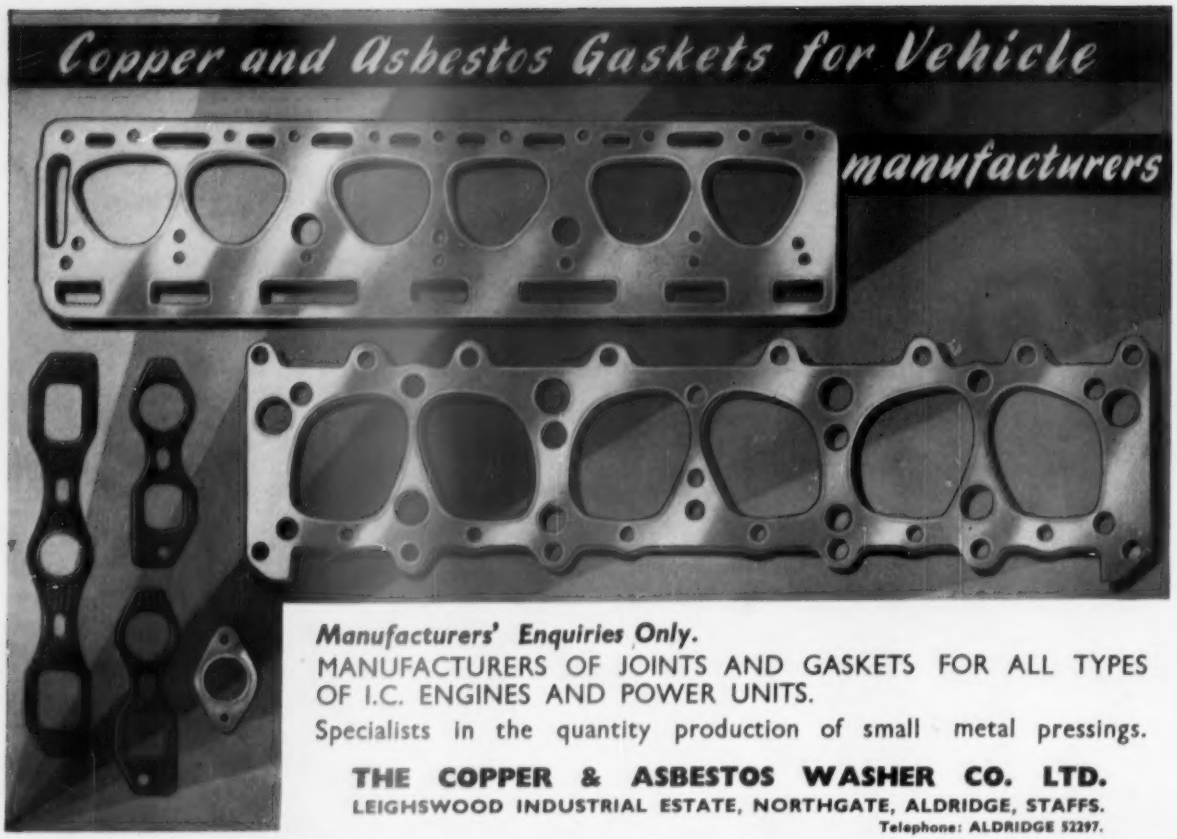
The Austin Motor Company Limited, Longbridge, Birmingham



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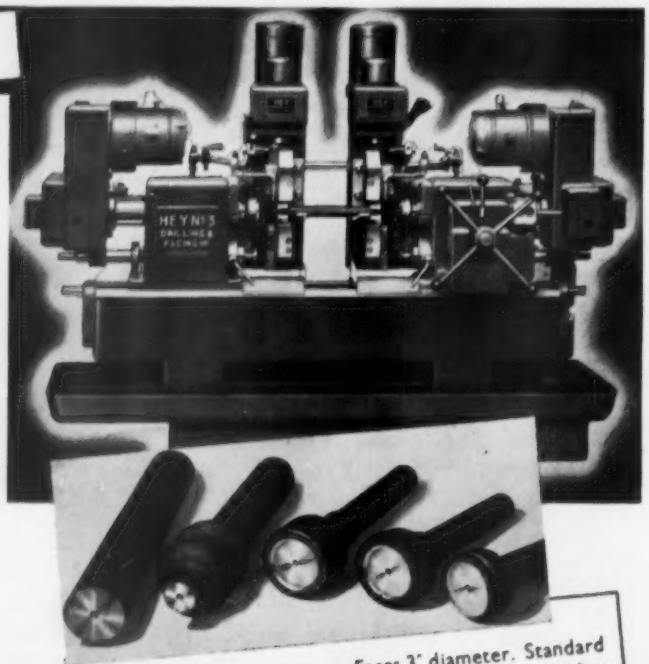

HEY No. 3 DOUBLE ENDED CENTRING & FACING MACHINE

- *Perfect alignment of centres*
- *True faces and accurate lengths*
- *Turned finish on faces*
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Faces 3" diameter. Standard Vices have maximum bar capacity of $6\frac{1}{2}$" diameter. Minimum length handled 6". Standard bed lengths to take work up to 24", 48" or 72" long.

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The far-reaching results of cylinder wear are becoming realised by Transport Engineers. It means premature overhauls, the costs of which are continuously rising.

Are you prepared with the answer? CROMARD hard chromed steel cylinder liners with a 100,000 road-miles guarantee.

This is what the "Automobile Engineer" says :—

"The object in chromium plating is of course to reduce bore wear. In fact almost unbelievable small rates of wear have been experienced with Cromard liners. These claims . . . . have been substantiated by a number of independent observers."

(*October*, 1953)

CROMARD liners are used throughout the World. There are over 120 fitting stockists throughout the British Isles.

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The most vital job in your shop

Lubrication is the vital link that makes everything tick. The most modern and most ancient machine tools alike need correct lubrication to maintain their performance.

Aiding you in this essential phase of machine shop maintenance are the GENA lubricants. They comprise seven oils of graded viscosity ratings and cover most requirements. Ask for your copy of "Machine Tool Lubrication" and you will see how FLETCHER MILLER lubricants can serve your machine shop.

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VETA—for hydraulic systems generally

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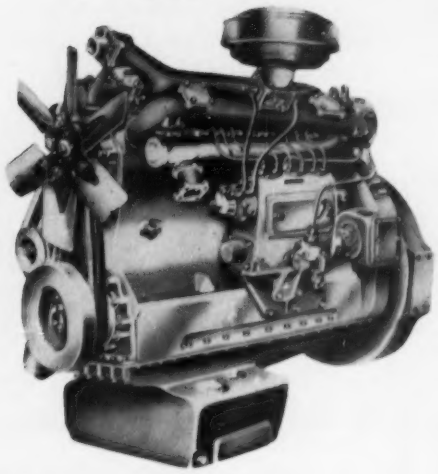
MEADOWS

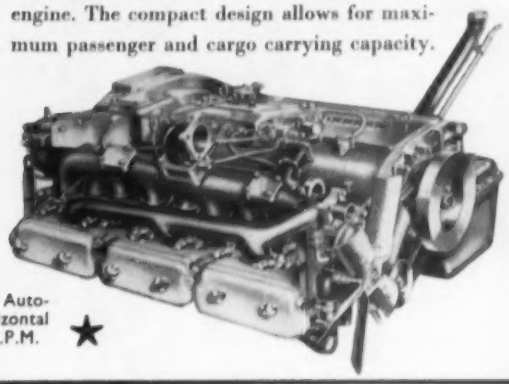
announce

4 new DIESEL ENGINES



The Meadows 6DC500 Automotive diesel engine. 135 B.H.P. at 2400 R.P.M. ★

To the Meadows range of automotive power units are now added four new engines — providing even greater flexibility within the power range of 42-270 B.H.P., and greater adaptability through both vertical and horizontal versions of each engine. The new "500" engines are powerful 8 litre, 6 cylinder units based on the well proven Meadows "330" engine. The compact design allows for maximum passenger and cargo carrying capacity.



The Meadows 6HDC500 Automotive diesel engine in horizontal form. 135 B.H.P. at 2400 R.P.M. ★

THE MEADOWS RANGE

TYPE		POWER	SPEED	MAXIMUM TORQUE	SUITABLE FOR	
					GOODS VEHICLES TONS CAPACITY	PASSENGER VEHICLES SEAT CAPACITY
4DC330	VERTICAL	90 BHP.	2400 RPM.	230 16/ft. @ 1400 RPM.	8	37-41
4HDC330	HORIZONTAL	90 BHP.	2400 RPM.	230 16/ft. @ 1400 RPM.	8	37-41
4DC420	VERTICAL	85 BHP.	1900 RPM.	280 16/ft. @ 1200 RPM.	—	—
6DC500	VERTICAL	135 BHP.	2400 RPM.	345 16 ft. @ 1450 RPM.	12/14	37-56
6HDC500	HORIZONTAL	135 BHP.	2400 RPM.	345 16/ft. @ 1450 RPM.	12/14	37-56
6DC630	VERTICAL	130 BHP.	1900 RPM.	420 16/ft. @ 950 RPM.	15/20	37-56
6HDC630	HORIZONTAL	130 BHP.	1900 RPM.	420 16/ft. @ 950 RPM.	15/20	37-56
6DCS630	VERTICAL	185 BHP.	1900 RPM.	540 16 ft. @ 1300 RPM.	50	37-56
6CD970	VERTICAL	180 BHP.	1650 RPM.	645 16/ft. @ 1000 RPM.	100	—
6DCS970	VERTICAL	270 BHP.	1650 RPM.	900 16/ft. @ 1200 RPM.	150	—

Matched 5 speed gearboxes are available for each model. A special synchromesh mechanism is now incorporated in the type 250C5 and 350C5 gearboxes. The Meadows 250C5 synchromesh gearbox is exhibited in sectionalised form.

Obtain full details of the New Meadows diesel engines and gearboxes on Stand 317, first floor, Commercial Motor Show.

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MACHINE FIXING GLUE
COOPERS FELT

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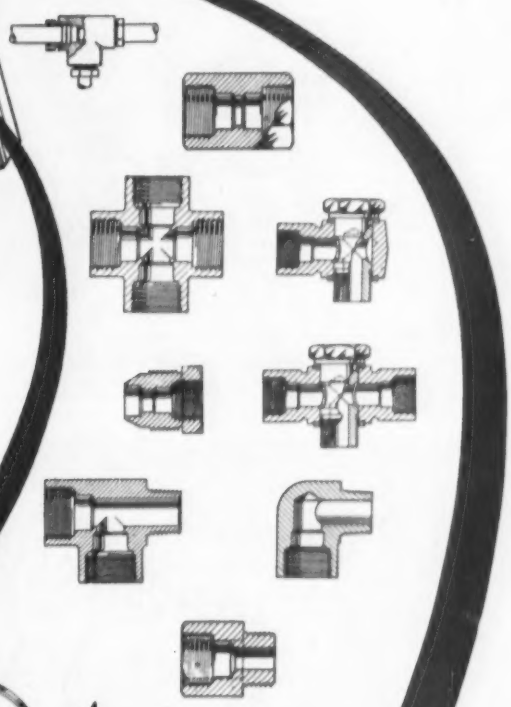
Fitted any good unions lately?



More and more manufacturers are standardizing on Enots brass solderless unions because :

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Enots

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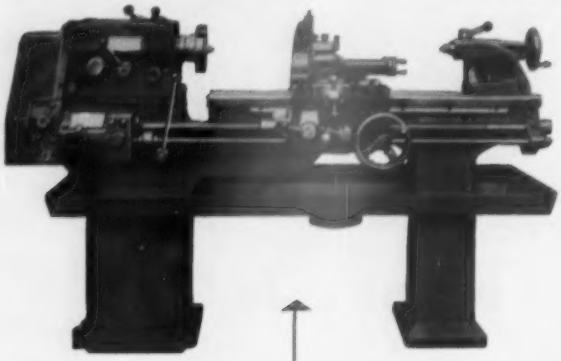

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'70' junior 7" centre lathe

'85' 8½" centre lathe

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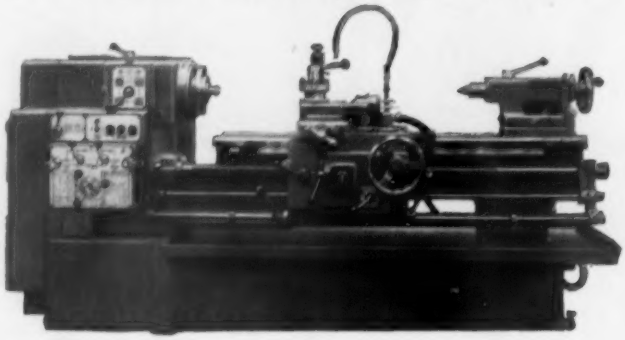
8 SPINDLE SPEEDS 30—874 r.p.m. Spindle mounted on selected taper roller bearings • Diagonally braced bed • Nickel steel gears on multi-splined shafts • Inverted vee and flat guides • Single lever selection of feeds • Tension mounted lead screw • Oil immersed multi plate clutch.

12 SPINDLE SPEEDS 21—945 r.p.m. Rigid one piece fabricated steel base • Rapid spindle speed selection • Feed reverse control from apron • Totally enclosed auto lubricated quick change feed gear box.



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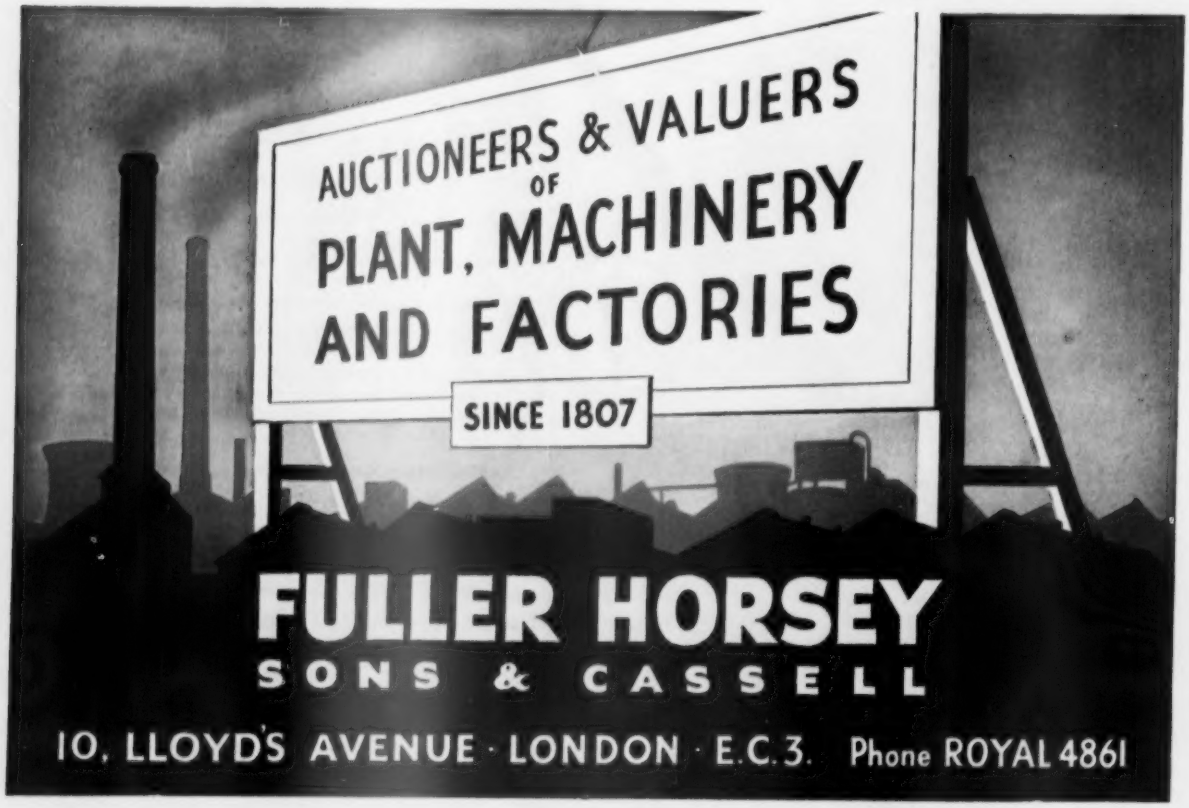

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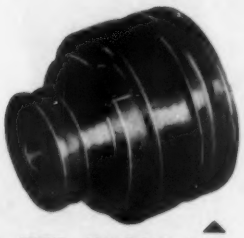

HIGH SPEED MULTIPLE DISC CLUTCHES

This design is particularly suitable for machine tool drives and for other machinery running at high speed. The clutch is very powerful for its size; it has a clean contour and it incorporates a compensating feature which eliminates frequent adjustment.

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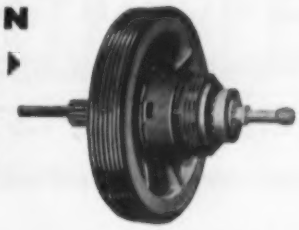
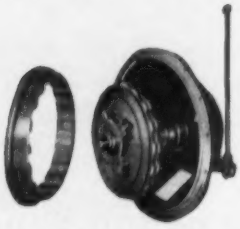
Suitable for presses, shearing machines, expanding and contracting machines, forging machines and all heavy duty drives of frequent operations.



FLEXIBLE COUPLINGS

This Elliptical Rubber Buffer Flexible Coupling is extremely efficient. The two shafts are free to move axially and the shape and flexibility of the Rubber Buffers ensure that even pressure is exerted by each Driving Lug. Suitable for either direction of rotation.



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Complete self-contained units for Diesel and Petro engines to drive all kinds of machinery. Range of sizes to suit medium and large powers and speeds.

CLUTCH-BRAKE ASSEMBLIES

The illustration shows a pneumatic Clutch-brake Assembly supplied for a 500 ton Forging machine. Duty 1,100 h.p. at 42 r.p.m. frequency 3-4 strokes per minute.

...AND AIR/GAS HANDLING PLANT

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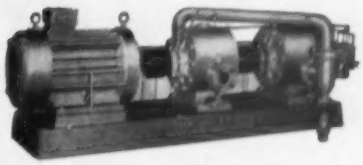
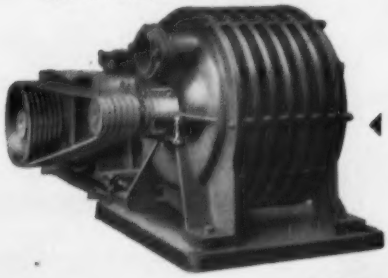
Two Stage Rotary Compressors having a free air capacity of 1000 C.F.M. at 100 lb/sq. inch pressure. Full range of machines available up to 2070 C.F.M. displacement.

ROTARY VACUUM PUMPS

Two Stage Rotary Vacuum Pump. 290 C.F.M. displacement, 29.98 inches H.C. Full range of machines available up to 2070 C.F.M. displacement.





TURBO BLOWERS AND EXHAUSTERS

Range available up to 7½ lb/sq. inch pressure and 10 inches of Mercury Vacuum.

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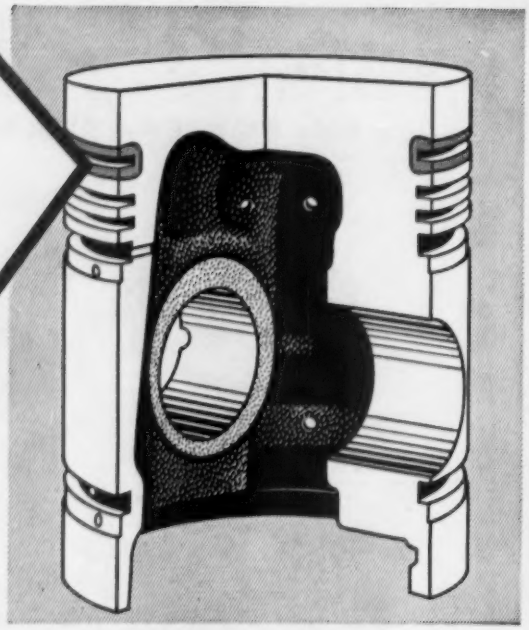
WELLWORTHY AL-FIN
armoured ring groove
LONG LIFE PISTONS



An Al-Fin armoured ring groove piston. The top ring groove has an austenitic cast iron insert bonded *to the alloy giving strength where it is required, prolonging piston life by at least* 100%.

more than pay for themselves in the first year . . . . BECAUSE

The average life of an Al-Fin Piston is at least 100% more than normal types. This double mileage saves you the cost of one overhaul *and* the cost of another set of pistons. To this can be added the further saving effected by keeping the vehicle on the road during the whole period. No wonder so many large fleet owners say:—

AL-FIN is the best investment yet

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AL-FIN

'The Choice of the Expert'

BONDED INSERT PISTONS WELLWORTHY LIMITED, LYMINGTON, HANTS

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G.E.C.

INFRA-RED PAINT REPAIR UNITS

- all coats applied — and dried — in **one** day
- no blooming

Standard drying times for small patches

Primers and stoppers	10 minutes
Cellulose finishes	20 minutes
Synthetic finishes	30 minutes

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has a greater tensile strength than some steels with the castability and machineability of iron

GRADE	Ultimate Tensile Stress Tons/sq. in.	Yield Stress Tons/sq. in.	Elongation % (on 2 in.)	Transverse Rupture Stress Tons/sq. in.	Compression Strength Tons/sq. in.	Impact Izod. 10 mm. sq. notched ft. lb.	Brinell Hardness
PEARLITIC — —	35–45	25–35	1–5	55–65	65–80	4	230/280
PEARLITIC/FERRITIC	32 min.	24 min.	5 min.				
FERRITIC — —	27/35	20/25	10/25	55/60	48/58	12	140/180

With Lloyds Ductile Iron, the graphite flakes common to ordinary cast iron are present in the form of spheroids. It can be cast as accurately and as easily as ordinary cast iron, but compared with flake-graphite iron is stronger, tougher and ductile.

Lloyds Ductile Iron is now being used for a wide range of engineering parts and in some instances is replacing cast or forged steels, malleable iron and non-ferrous metals. It also replaces grey iron, permitting reduced section thickness to take advantage of the better properties offered and it may well enable you to re-design your present castings for more efficiency.

The successful casting of Ductile Iron demands the strictest and most experienced metallurgical and melting control, but Lloyds have been casting it daily, continuously since 1950! Technical advice freely given on request.

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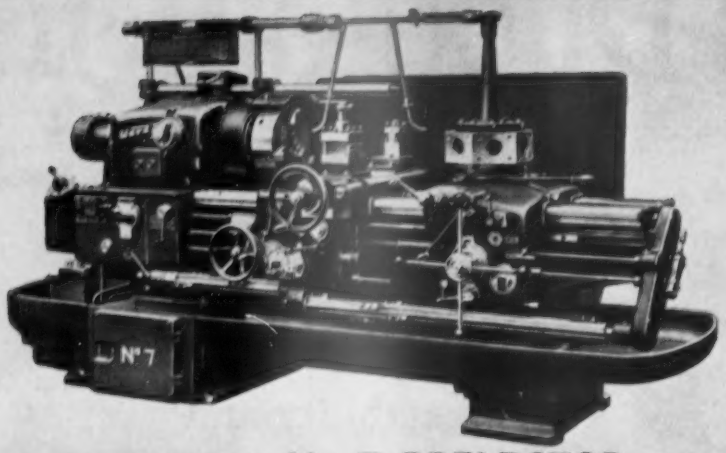
For Maximum Production



Capacity: 2⅛ in. dia. hole through spindle. 16 in. dia. swing over stainless steel bed covers.

Spindle: Mounted in ball and roller bearings.

Powerful metal-to-metal cone clutches transmit power through ground gears.

New features include patented hydraulic preselecting speed change system allowing for setting any operation speed whilst the previous operation is running. Maximum production is ensured by making full use of Tungsten Carbide cutting tools.

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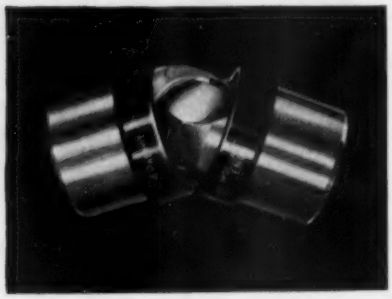

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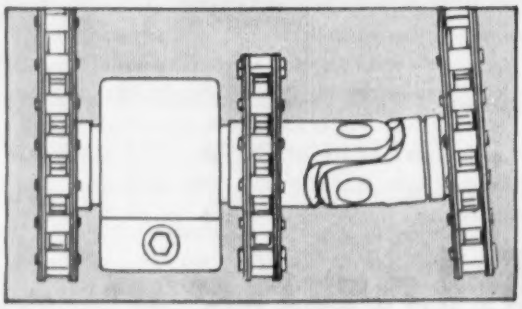

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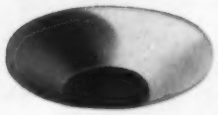

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advantage

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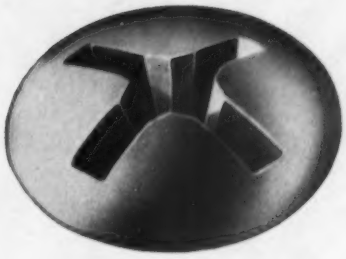

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Always silky smooth a Turquoise eases your work. No flaws to spoil your line or paper. The 100% Electronic Graphite cleansed and refined to particles of 1/25,000th inch results in a smoother, more compact lead.

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'CHEMI-SEALED' Super-bonded
TURQUOISE
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with 100% 'ELECTRONIC' Graphite
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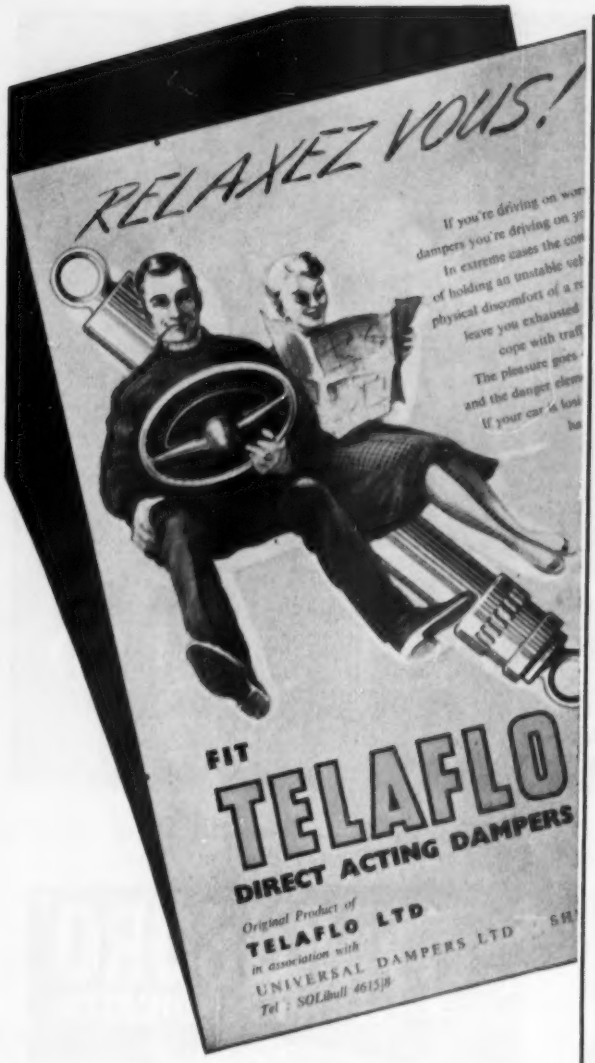


A recent Telaflo advertisement to be featured throughout the motoring press

EXTRA SALES!

Win new customers and keep them by joining the Telaflo Sales and Service link-up. Let the quality of Telaflo products and the sustained and imaginative advertising which presents them to the public enhance *your* reputation. Satisfied customers become regular visitors which means **EXTRA Sales in all departments.**

You **can sincerely endorse these Telaflo claims: smoother travel and improved road-holding through greater shock-absorbing capacity, elimination of frothing, better cooling, rugged construction, unfailing reliability.**

Supplied with all types of end fittings to suit most makes of car. Write now for details and terms.

The Adjustable Ride Control Telaflo is fitted to the 1956 Sapphire 346. Soon to be available for other makes of car.

TELAFLO

DIRECT ACTING DAMPERS

Original Products of **TELAFLO LTD**
in association with

UNIVERSAL DAMPERS LIMITED, SHIRLEY, BIRMINGHAM *Telephone:* SOLihull 4615/8

3844

FOR Diecastings as strong as steel

ALUMINIUM BRONZE CO. LTD.

Wallows Lane · Walsall · Staffs.

Telephone WALSALL 2108 (3 lines)
Telegrams "ABCO WALSALL"

Collier's
TRADE MARK

WORM DRIVE
HOSE CLIP

The Most Positive Worm Drive

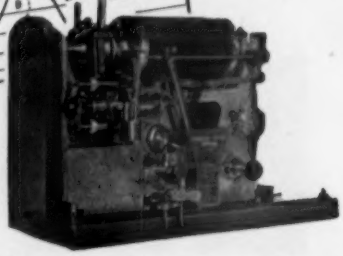
The slots are pierced right through the band, thus affording the worm or screw an absolutely certain grip under all conditions.

Telephone DIDCOT 2046

COLLIER & COLLIER LTD
BOATS DIDCOT

DOBBIE McINNES
'FARNBORO'
ELECTRIC INDICATOR

Large Diagrams up to 14½" × 7½"



No complex electric circuits. Replacements are negligible. No glass components. Simplicity ensures ready understanding and manipulation without special knowledge. Very large diagrams. No Photography, thus saving time and trouble. Calibration Lines can be recorded while taking diagrams.

DOBBIE McINNES LTD.

Nautical and Engineering Instruments

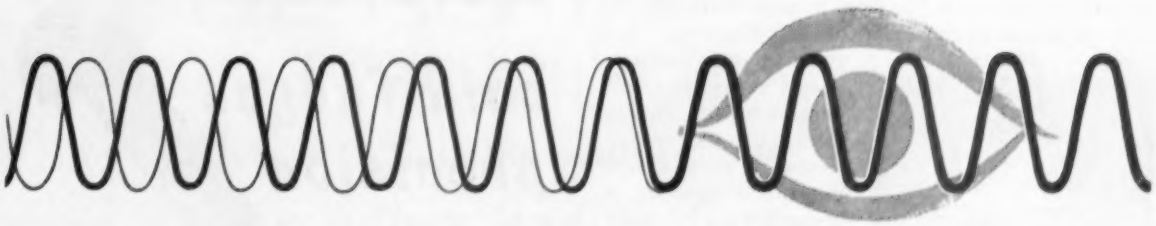
BROOMLOAN ROAD, GLASGOW, S.W.1

Also at South Shields · Liverpool · London

Electronic control does it quicker

Automatic control cuts out innumerable hold-ups in production and adds valuable time to every working day. It can be applied in a great many different ways, from a simple timer that stops and starts machines, to the complex feed-back devices that regulate machines against a standard reference while they are in action, as in register control on colour-printing presses.

Whatever your process you would find it well worth while to consider automatic control in one form or another. It is more exact than is humanly possible; rejects are reduced; quality is improved; the flow of production is quicker and smoother; it uses little current and calls for little maintenance. In fact, you get higher production at lower cost. This is only one of the ways in which electricity is playing a vital part in the drive for higher productivity.



Electricity for Productivity

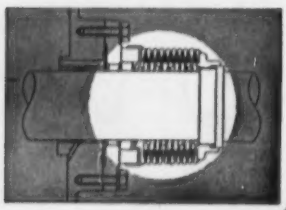
Ask your ELECTRICITY BOARD for advice and information, or get in touch with E.D.A. They can lend you, without charge, films about the uses of electricity in industry. E.D.A. are also publishing a series of books on Electricity and Productivity. Titles now available are: Electric Motors and Controls, Higher Production, Lighting, Materials Handling, and Resistance Heating. Price 8/6, or 9/- post free.

Issued by the British Electrical Development Association, 2 Savoy Hill, London, W.C.2

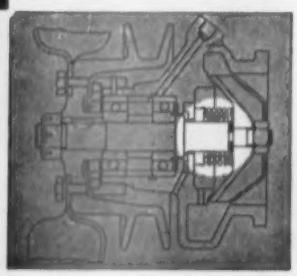
Teddington

Photograph by courtesy of London Transport Executive.

TEDDINGTON Shaft Seals are ideal for shafts running at speed. For example a 3½" dia. shaft running at 2,000 R.P.M. in temperatures up to 300°F is quite normal. As peripheral speed of the rubbing surfaces is the deciding factor, they can be fitted to larger shafts running at lower speeds or to smaller ones at high speeds. They will retain most liquids or vapours at pressures from 30-in. vacuum to 250 lbs. per sq. in., and are unaffected by continuous or intermittent running, or reversing.



The British Thermostat Company are the largest manufacturers of metallic bellows in Europe and, during the last 25 years, have acquired unique experience in the design and application of metallic bellows and packless shaft seals. Write for Leaflet NS.5.



THE BRITISH THERMOSTAT CO. LTD.
SUNBURY-ON-THAMES, MIDDLESEX
Telephone : Sunbury-on-Thames 456

Telegrams & Cables: THERMOSTAT, SUNBURY-ON-THAMES, TELEX
Telex: 2-2742 TEDDCONTSNBRY

Adjustable TENSION WRENCHES

NEW NUT TIGHTENING TORQUE DATA *Leaflet available*

SPEED WITH ACCURACY

STURDY & RELIABLE.
COMPACT DESIGN.
ADJUSTABLE.
3 PHASE SIGNAL BY SIGHT, SOUND & FEEL.
LOW PRICE.

6 Models cover 2-400 foot lbs for ⅜" ½" and ¾" Sq. Drive

TOOL UP WITH

CHROME ALLOY STEEL **BRITOOL** SERVICE TOOLS

JENKS BROS. LIMITED,
BRITOOL WORKS, BUSHBURY, WOLVERHAMPTON, STAFFS.

See our Stand No. 181, Transport Service Equipment Section, Commercial Vehicle Exhibition, Earls Court.

cold forged precision by

Commercial Motor Show, Earls Court, 21st—29th September, Stand 288, Avenue C.

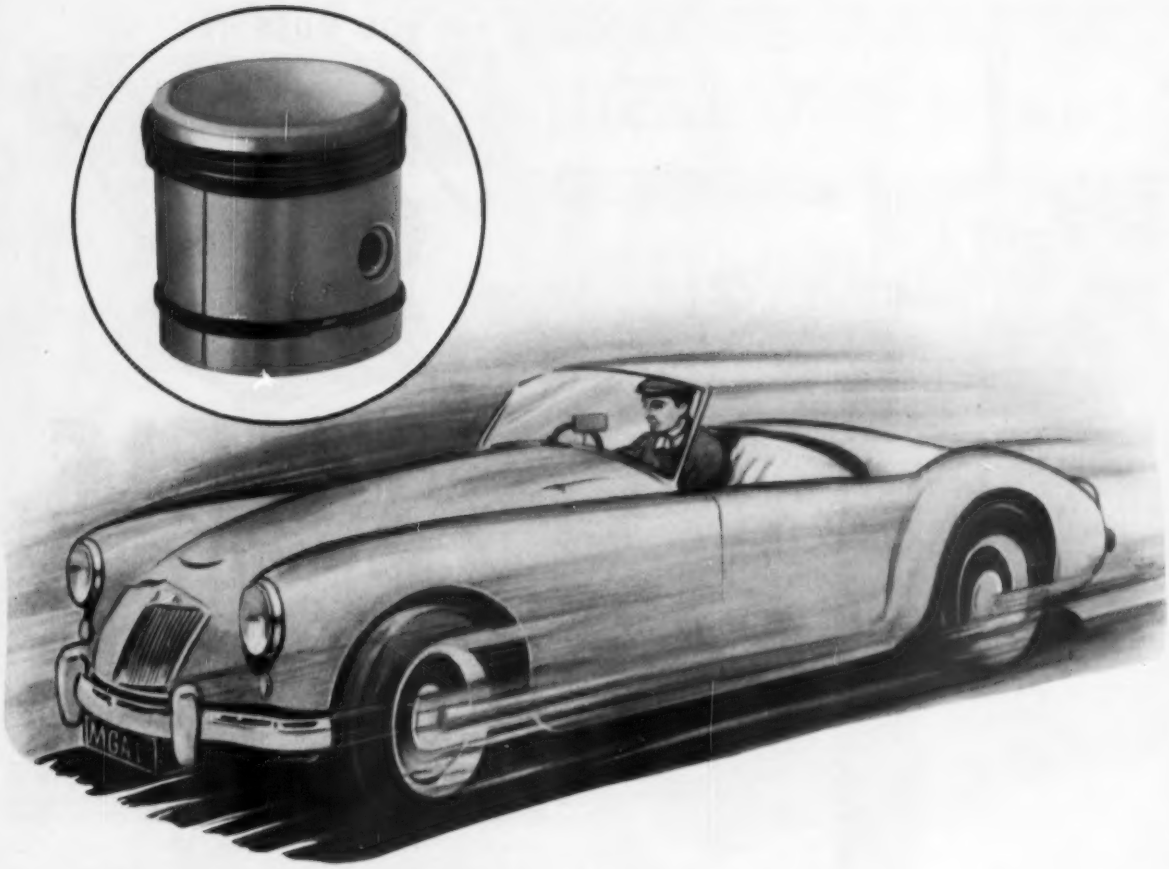
Motor Show, Earls Court 17th—27th October, Stand 291, Avenue C.

LINDLEY'S

QUALITY BOLTS, NUTS and SET SCREWS

C. LINDLEY & CO. LTD., ENGLEFIELD ROAD, LONDON N.1

Phone: CLissold 0643 (4 lines) Grams BEAUVOIR, NORDO, LONDON



B.H.B. PISTONS

provide the punch in the M.G.A. 1½ litre sports car and in many other leading British cars

including:—

AUSTIN CAMBRIDGE : AUSTIN WESTMINSTER : M.G. MAGNETTE
MORRIS OXFORD SERIES II : MORRIS MINOR SERIES II
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(One of the Sheepbridge Engineering Group)

THE GREEN, TWICKENHAM · Telephone : POPESGROVE 2206-9 · Telegrams : MOTIF TWICKENHAM

Intal stands on its own good name

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THE INTERNATIONAL TWIST DRILL CO. LTD.
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Telephone : 23072-3 Telegrams : Fluted, Sheffield
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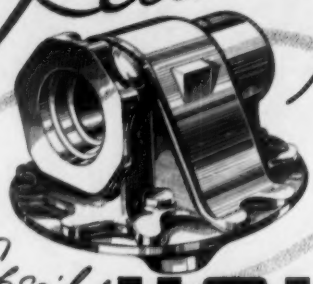
Phone: CITy 6994

· IF YOU MUST HAVE

Reliability

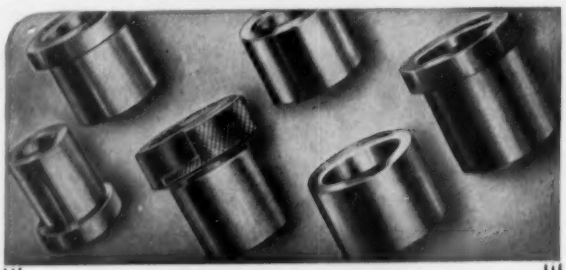


Specify **HALE**

Finest blackheart **MALLEABLE IRON CASTINGS**

SEND FOR DETAILS OF OUR FILM "MODERN MALLEABLE"

HALE & HALE (TIPTON) LIMITED DUDLEY PORT Staffs



THE BUSH PEOPLE for NITRIDED JIG BUSHES and LINERS

NEW CATALOGUE AVAILABLE ON REQUEST

These jig bushes and liners are manufactured in accordance with B.S.S. 1090: 1953 the recommended sizes for the jig place holes being in accordance with British Standard for B limits (B.S.S. 164:1941).

Established 30 years

LAWRENCE Bros. MILLWARD LTD
WICKERSLEY
ROTHERHAM

ELECTRO-MECHANICAL UNIT HEADS and SPECIAL MACHINES

DRILLING

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TAPPING

SPOTFACING

MILLING

Sentinel-Renault electro-mechanical unit heads and special machines offer the production engineer an effective and economical solution to many production problems. Wherever there is repetition work to be done—involving one or more of the operations given above—Sentinel-Renault equipment can be successfully applied.

Sentinel-Renault unit heads and special machines are now available on attractively short delivery terms. Have *you* had a copy of our booklet describing their range and application?

Sentinel (Shrewsbury) LTD. SHREWSBURY

TELEPHONE SHREWSBURY 2011 · GRAMS: SENTNOLL SHREWSBURY

A METAL INDUSTRIES GROUP COMPANY

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S523/3664

For duties that demand
the highest standard of reliability

The Douglas "Tugmaster" for use on airfields, is powered by a Rolls-Royce B.80 engine.

ROLLS-ROYCE

Petrol Engines

With power output from 80 to 200 h.p., the Rolls-Royce 'B' Range petrol engines are designed for those applications which demand compactness, good power/weight ratio and the highest standard of reliability.

Maintenance and storekeeping are simplified by the fact that 90% of the wearing parts in the 4, 6 and 8-cylinder engines are common to all three. A fully automatic transmission can also be supplied with these engines.

ROLLS-ROYCE LIMITED, CREWE, CHESHIRE

'LONDON' BRAND
TINNED & LEADCOATED
STEEL SHEETS
for the automobile industry

'London' Brand are worth specifying by name because of their superior ductility and general working-up qualities. Direct delivery in our own vehicles to all parts of Great Britain ensures that loads arrive on time and in perfect condition. Stocked by leading Merchants.

Illustrated brochure of useful data sent on request. Write for your copy to-day.

SHIMWELL & Co. LTD
MANUFACTURERS SINCE 1875
WELLINGTON ROAD · LEYTON · LONDON · E.10
Tel: LEYtonstone 2281-2

P.V.C. WING PIPINGS as supplied to leading motor manufacturers and body builders at home and abroad, have proved that plastic materials survive the severest tests. Whether as standard fittings used as wheel arch pipings or specially designed joint mouldings our sections are guaranteed to meet your particular requirements. Extrusions are our business — not just a department.

Please write for brochure on extrusions for the motor industry.

C. & C. MARSHALL LTD.
PLASTRIP HOUSE
OAKLEIGH ROAD NORTH, LONDON, N.20
Telephone: Hillside 5041 (3 lines) Cables: Tuflex, London
Telegrams: Tuflex, Norfinch, London

TUFFLEX

A QUICKER MALLEABLE IRON SERVICE

Gloucester have virtually revolutionised the production of Blackheart Malleable iron. Their adoption of the new electric annealing process – for the first time in Britain – cuts annealing time from days to hours.

Every heat is under continuous laboratory control and castings are rigidly inspected at every stage of production.

GLOUCESTER

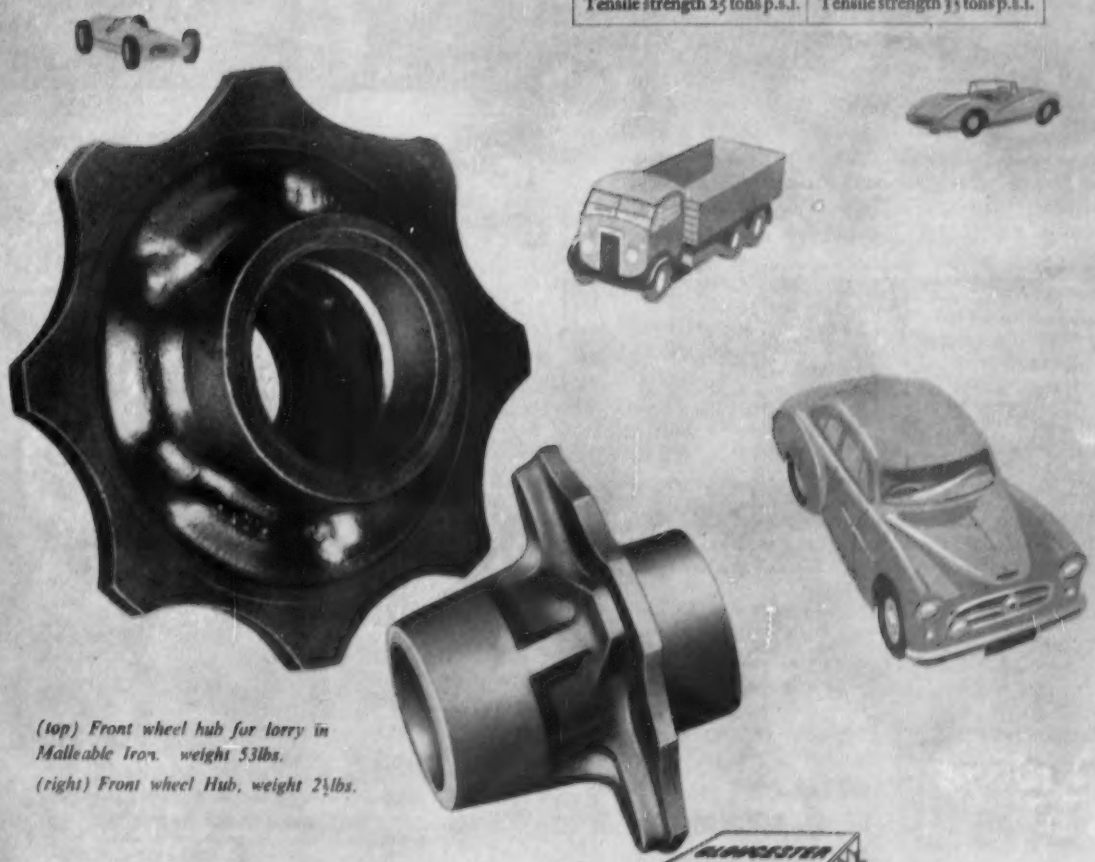
malleable & grey iron castings

Gloucester Blackheart Malleable iron has superb mechanical properties, combining great strength and rigidity with easy machineability. The castings meet design requirements to an exceptional degree of accuracy and are tough and resistent to impact.

Always consult Gloucester at the designing stage – even before – their experience and resources are placed unreservedly at your disposal.

The following are typical Gloucester Malleable specifications.

Gloucester Blackheart Malleable		*Gloucester Lamellar Pearlitic Malleable*	
Elongation	18%	Elongation	5%
Yield Point	15 tons	Yield Point	22 tons
Tensile strength	25 tons p.s.i.	Tensile strength	35 tons p.s.i.



(top) Front wheel hub for lorry in Malleable Iron. weight 53lbs.
(right) Front wheel Hub, weight 2¼lbs.

GLOUCESTER FOUNDRY LTD., EMLYN WORKS, GLOUCESTER
(A subsidiary of the Gloucester Railway Carriage & Wagon Co. Ltd.)

GLOUCESTER THE HOME OF GOOD CASTINGS

Telegrams: 'Pulleys' Gloucester
Telephone: Gloucester 23041

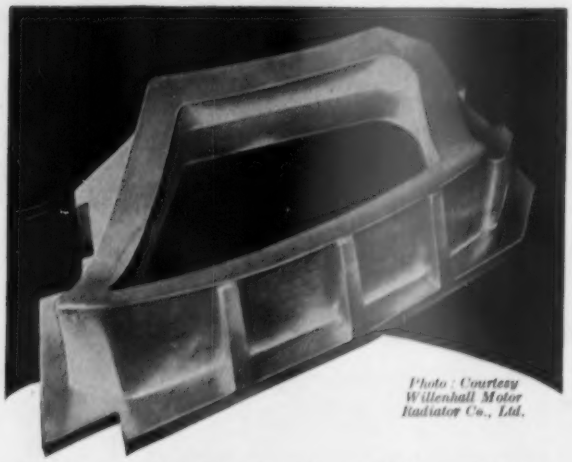


Photo : Courtesy Willenhall Motor Radiator Co., Ltd.

Press Tools & Stretcher Dies

AT A FRACTION OF THE COST using

KIRKSITE 'A'

LOW COST - SPEED - HIGH RECOVERY VALUE

Cost of dies made with KIRKSITE 'A' is only a fraction of those made of steel or cast iron, the more intricate the tool the greater is the saving. Use of KIRKSITE 'A' also means that dies can be produced in a few days eliminating long waiting periods for tools. A complete and speedy service for the production of both patterns and dies is operated. KIRKSITE 'A' data gladly sent on request. Also the Hoyt Buyers' Guide, listing all the Hoyt products and services.

PRODUCTION RUNS OBTAINED FROM KIRKSITE PRESS TOOLS

Kirksite 'A' and Plastics: *Kirksite is specially suitable for metal moulds for Polyester resins, having a very long life under operating conditions with Polyesters, whether plain or reinforced.*

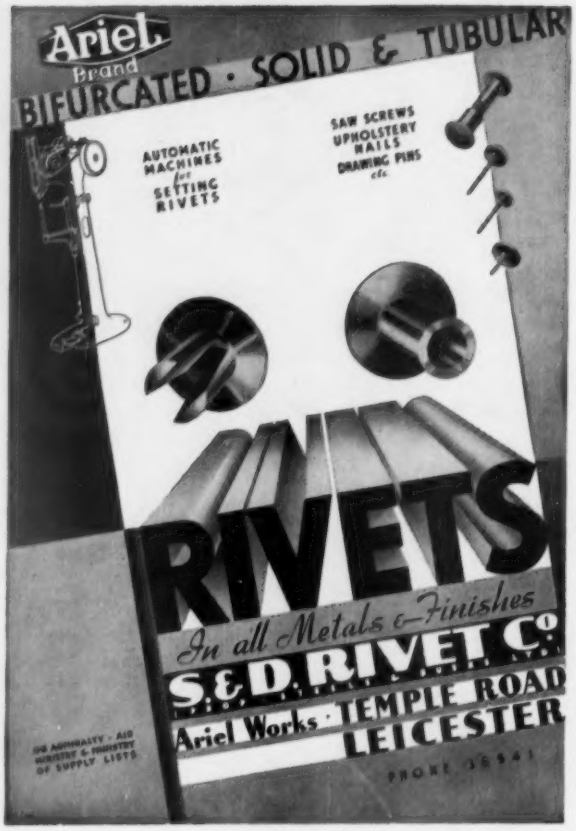
200,000	Petrol tank pressings in 20 gauge steel from one KIRKSITE punch.
60,000	Aircraft jettison tanks in 16 gauge steel.
20,000	Delivery van sides in 20 gauge steel.
20,000	Runs in aluminium alloy sheet without any appreciable wear on tools.
50,000	Special plastic helmets on one set of KIRKSITE tools.
25,000	Special rubber parts from a KIRKSITE mould.

All the above tools were still serviceable.

HOYT LONDON METAL CO. OF GT. BRITAIN LTD.

DEODAR ROAD, PUTNEY, LONDON, S.W.15.
Telephone: VANdyke 6061.

PLAIN BEARINGS · ANTI-FRICTION METALS
BRONZES & LEAD BRONZES · FUSIBLE ALLOYS, ETC.



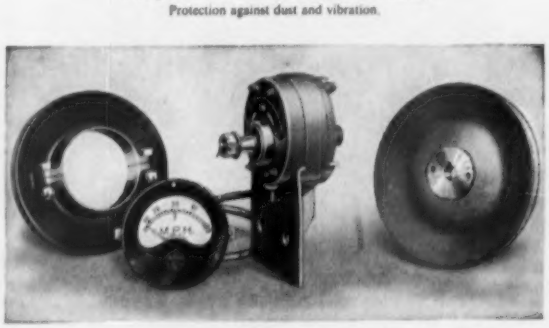
B T-H

Speed-indicators for Road Vehicles

Reliable indication of road speeds is essential in view of the provisions of the Road Traffic Act. This indication must be steady and must be seen at a glance.

BTH were pioneers in the manufacture of electric speed-indicators for road vehicles, and the equipment is designed for the worst conditions likely to be encountered.

Advantages include:
Compact design — simple construction — few wearing parts.
No long flexible drive — thus ensuring greater accuracy.
Protection against dust and vibration.



BTH speed-indicating equipment, comprising (left to right) split pulley for transmission shaft, speed-indicator (voltmeter scaled in m.p.h.); generator with bracket and armoured cable; generator pulley. Generator can be supplied for direct drive if desired.

BRITISH THOMSON-HOUSTON
THE BRITISH THOMSON-HOUSTON CO. LTD. COVENTRY, ENGLAND

Member of the AEI group of companies

Improved Oil Sealing

Specify Weston Oil Seals
and 'O' rings at the blue print stage
And for all types of replacements

WESTON
OIL SEALS

CHARLES WESTON & CO. LTD.

Irwell Bank Works Douglas Green Pendleton Salford 6.

Telephone: Pendleton 2857-8-9; Birmingham: Midland 6952; London: Holborn 0414

...Who serve you well!

W

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Famous Quotations

"He that wrestles with us strengthens our nerves, and sharpens our skill. Our antagonist is our helper."

Edmund BURKE (1729-1797)

"Soon shall thy arm, unconquered steam, afar
Drag the slow barge, or drive the rapid car;
Or on wide waving wings expanded bear
The flying chariot through the field of air".

Erasmus DARWIN (1731-1802)

"England has saved herself by her exertions, and will, I trust, save Europe by her example".
Last Speech, Guildhall: Oct. 1805

Hon. William PITT (1759-1806)

"Pray, Mr. Opie, may I ask what you mix your colours with?", said a brisk dilettante student ... "With brains, Sir", was the gruff reply.

John OPIE, R.A. (1761-1807)

"If you can write a better book, preach a better sermon, or make a better mouse-trap than your neighbour, then, though your house be in a wood the world will make a beaten track to your door".

Ralph Waldo EMERSON (1803-1882)

BUT

IF YOU REQUIRE THE BEST
ALUMINIUM & NON-FERROUS CASTINGS
LET SANDWELL QUOTE

SCC

Specialists in the production of the finest quality Sand Castings, Gravity Die Castings and Pressure Die Castings in all Light Alloys and Non-Ferrous Metals by the most modern methods.

THE SANDWELL CASTING CO.
BANK STREET FOUNDRY, WEST BROMWICH
Tel: STOnecross 2231 (4 lines) · Grams: "REPCAST," WEST BROMWICH

Every part an integral one

As specialists in the manufacture of all types of springs, pressings, clips, and "Metpaks" Shock Absorbers, Brayhead put quality above all, and at the right price. No matter how small the components may be, each one is designed and made to meet the exacting standards of the leading industrialists who use them.

BRAYHEAD (ASCOT) LTD.
FULL VIEW WORKS · KENNEL RIDE · ASCOT · BERKS.
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FOR REALLY RUGGED WORK YOU NEED

Don
SINTERED METAL FRICTION MATERIALS
... second to none for:—
* Operative smoothness
* Frictional stability
* Long working life

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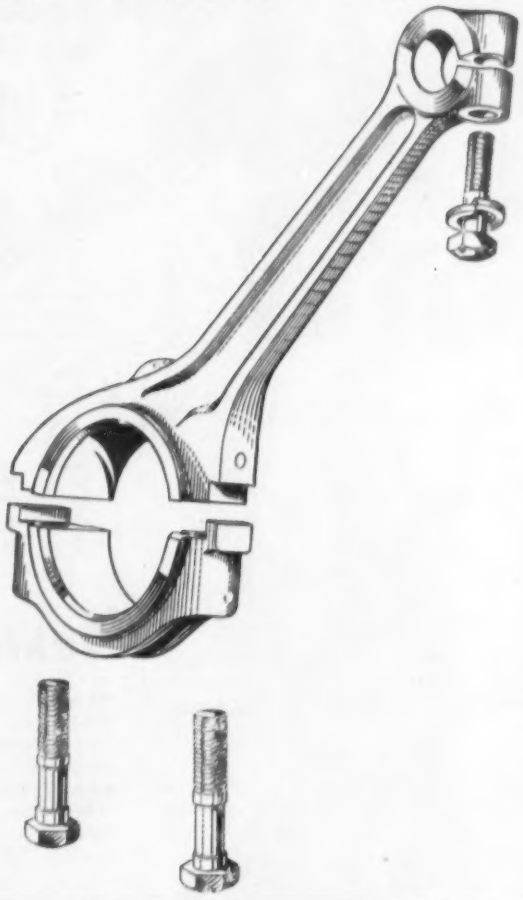
PARK GATE

QUALITY STEELS FOR DROP FORGINGS



black bars

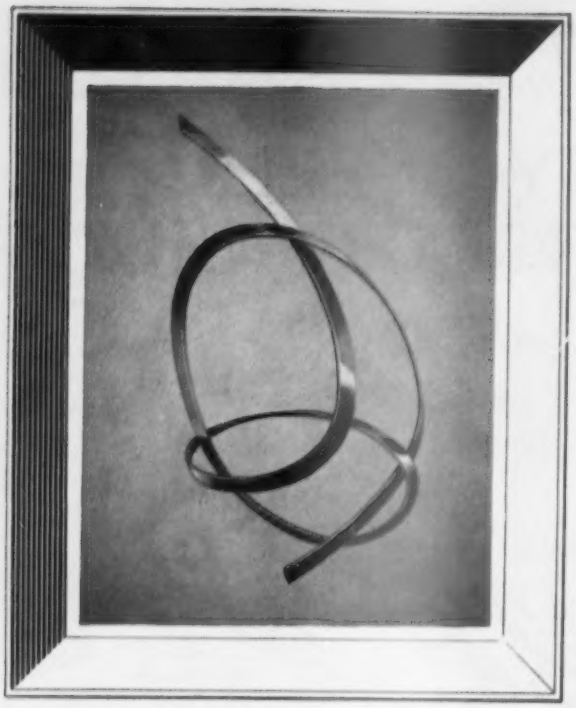
for

connecting rods

THE PARK GATE IRON & STEEL COMPANY LIMITED ROTHERHAM

TELEPHONE: ROTHERHAM 2141 (10 lines)

TELEGRAMS: YORKSHIRE, PARKGATE, YORKS



Portrait of a Piston Ring

ABOVE is an actual photograph of one segment of a Cords Piston Ring. This extreme flexibility is only one of the reasons why Cords are the most widely-used piston rings in the world.

IN THIS COUNTRY, Cords are mainly regarded as replacement rings, because of the extraordinary way they take up wear. Motorists know that by fitting them in a worn engine they avoid a costly re-bore.

BUT MANUFACTURERS of various types of engines and compressors have long fitted Cords as original equipment, after extensive tests in their own research departments had proved that Cords minimise wear in a *new* engine, and also considerably increase efficiency.

IF THAT SOUNDS INTERESTING to you, why not get into touch with us? We will tell you all you want to know about Cords, and gladly provide a set, to your requirements, for you to test in your own way.

CORDS

CORDS PISTON RING CO., LTD
906, Harrow Road, London, N.W.10
Telephone: LADbroke 7091 (3 lines)

WE SHALL BE ON STAND 292 AT THE COMMERCIAL MOTOR SHOW, SEPT. 21st—29th

—BUT ARE THEY ALL ALIKE?

EVEN A PEA MAY HAVE A HIDDEN GRUB, AND SO IN COMPONENTS FOR ENGINEERING—

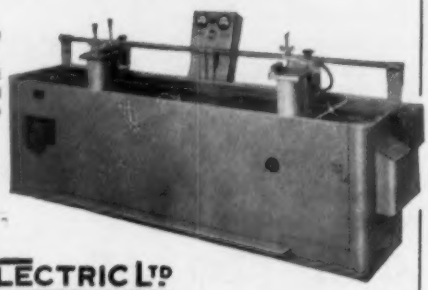
You can make certain of your own products being perfect by using—

FEL ELECTRIC

Electro-Magnetic Crack Detectors

THIS IS MODEL GP/U FROM OUR WIDE RANGE BUT WE CAN DESIGN AND MAKE TO YOUR PARTICULAR NEEDS

Send for Particulars



FEL ELECTRIC LTD
41 SIDNEY ST., SHEFFIELD 1

Taking the strain!

Movement, vibration, power stresses, these forces provide a constant tug-of-war with every bolt and nut. That is why engineers use Richards "HI-Strain" bolts which take such strains with maximum safety. Supplied Heat Treated to B.S.S. 1083 and B.S.S. 1768 Grade R Quality 45/55 tons tensile. Threads to Whitworth B.S.F., U.N.F. and U.N.C.

RICHARDS
hi-strain BOLTS

CHARLES RICHARDS & SONS LTD., Darlaston, South Staffs.
Phone: James Bridge 3188 (8 lines) P.B.X. Wires: "Richards, Darlaston."

Perfect Power Transmission

The propeller shaft carries the power to its final phase from which fast free-flowing movement results and in this respect Hardy Spicer propeller shafts and universal joints have proved their efficiency over and over again. Today, precision built Hardy Spicer equipment is standard on most British Cars. Replacement parts are available throughout the world.

HARDY SPICER
NEEDLE BEARING

UNIVERSAL JOINTS & PROPELLER SHAFTS

HARDY SPICER LIMITED · (*A Birfield Company*) · BIRCH ROAD · WITTON · BIRMINGHAM 6

NOW SATISFY YOUR DEMAND FOR **PERFECTION**

Use the *right* masking tape for every task. Permacel masking tape is used by most leading manufacturers. Here are examples of two tapes — and their uses.

Rover Car Co. Ltd.

The Use: Protecting machinery during manufacture.

The Tape: Permacel Self-Adhesive No. 30 Unbleached Cloth Masking Tape, made of unbleached cotton cloth, will stick instantly and firmly to any surface, yet comes away cleanly and easily. It is unaffected by many of the chemicals normally used in paints and dopes.

Avery-Hardoll Ltd.

The Use: Protection during the spraying of Petrol Pumps.

The Tape: Permacel Self-Adhesive Crepe Paper Masking Tape is a specially prepared tape for spray painting. It is highly flexible, readily conforms to uneven surfaces and goes around corners, evenly. It resists moisture and solvents in paints, varnishes, enamels and lacquers.

A GUIDE TO PERFECTION: *The Permacel brochure helps guide you through the intricacies of packaging tapes and subsidiary equipment. Over 400 examples classified. Send for your FREE copy to-day.*

PERMACEL
TRADE MARK

INDUSTRIAL MASKING TAPES

INDUSTRIAL DIVISIONAL Dept. A.E.

Johnson & Johnson (GT. BRITAIN) LTD., SLOUGH, BUCKS.

CALIBRATED JETS

Amal Limited make jet-calibrating machines for checking carburetter petrol jets to conform to British Standard No. 720 of 1948. Amal Limited are equipped to manufacture and calibrate jets from .005" to .5" dia. — all of which discharge a specified flow to within close limits under specified conditions. 'Amal' calibrated jets find many applications for metering the flow of other non-viscous liquids, and also of gases such as town gas, butane, propane, methane, etc.

AMAL

Service to the Motor and other Industries

AMAL LTD., WITTON, BIRMINGHAM, 6

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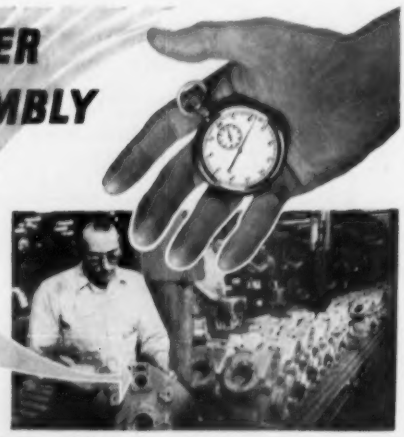
FASTER ASSEMBLY



WITH...

HELI-COIL
REGD TRADE MARK

SCREW THREAD INSERTS

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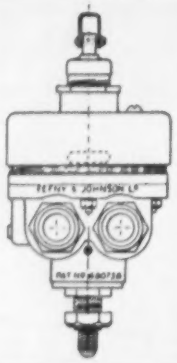

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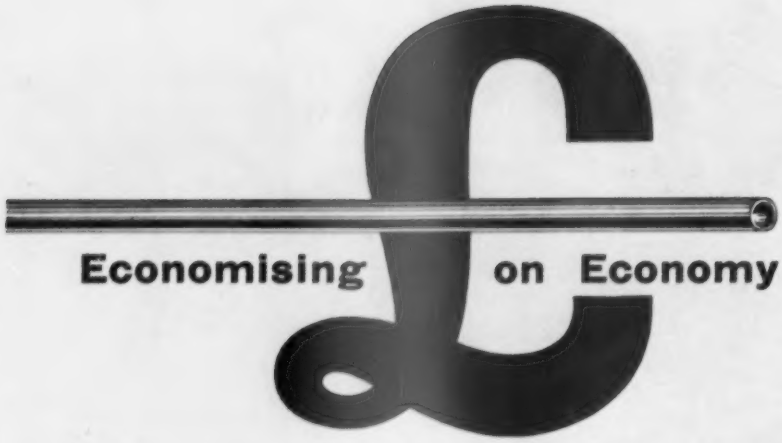

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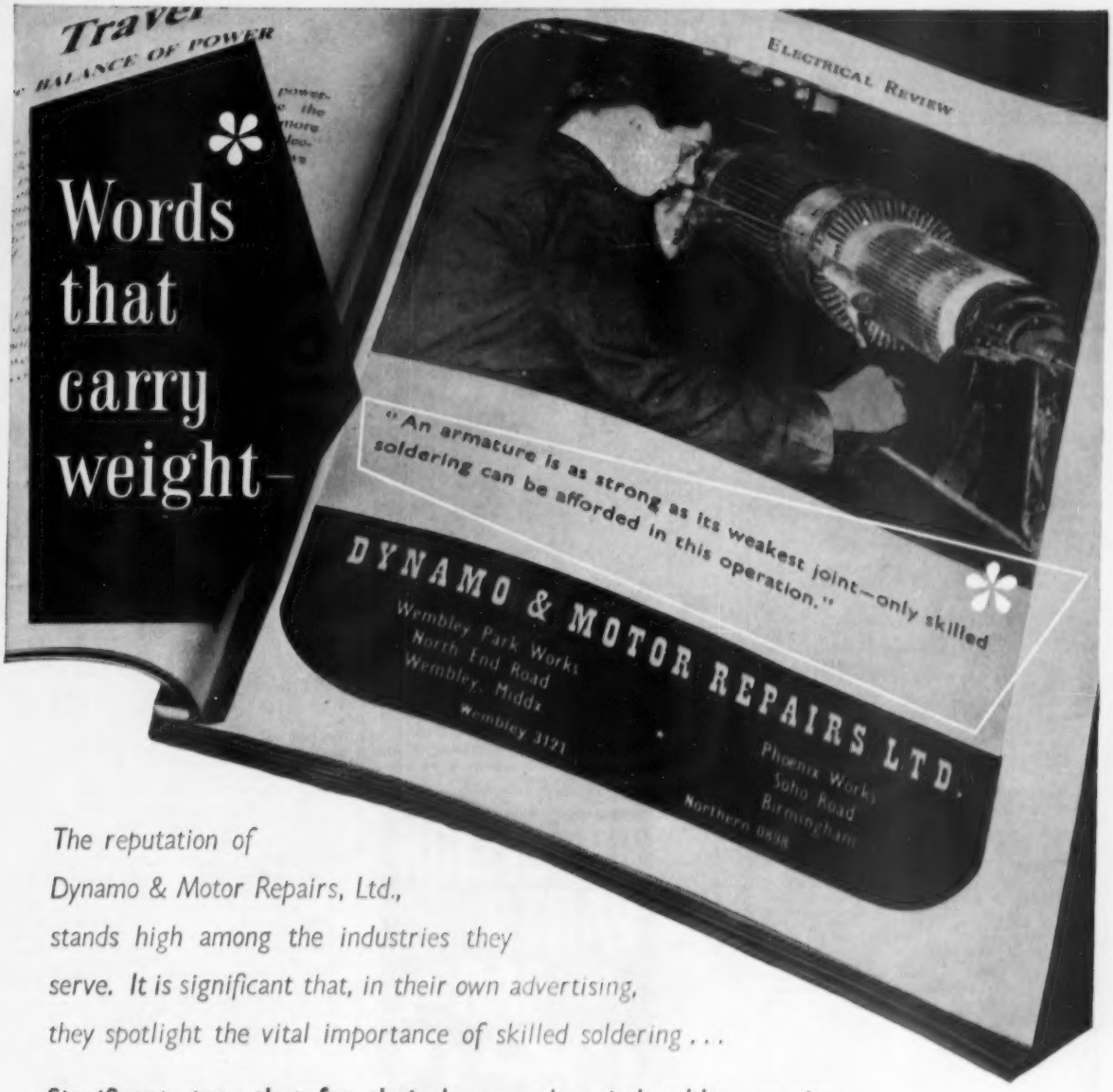

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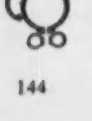

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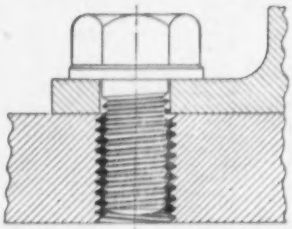

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